INTELLIGENT 100MHz OSCILLOSCOPE SYSTEM TYPE 5110

Operators Manual

GOULD

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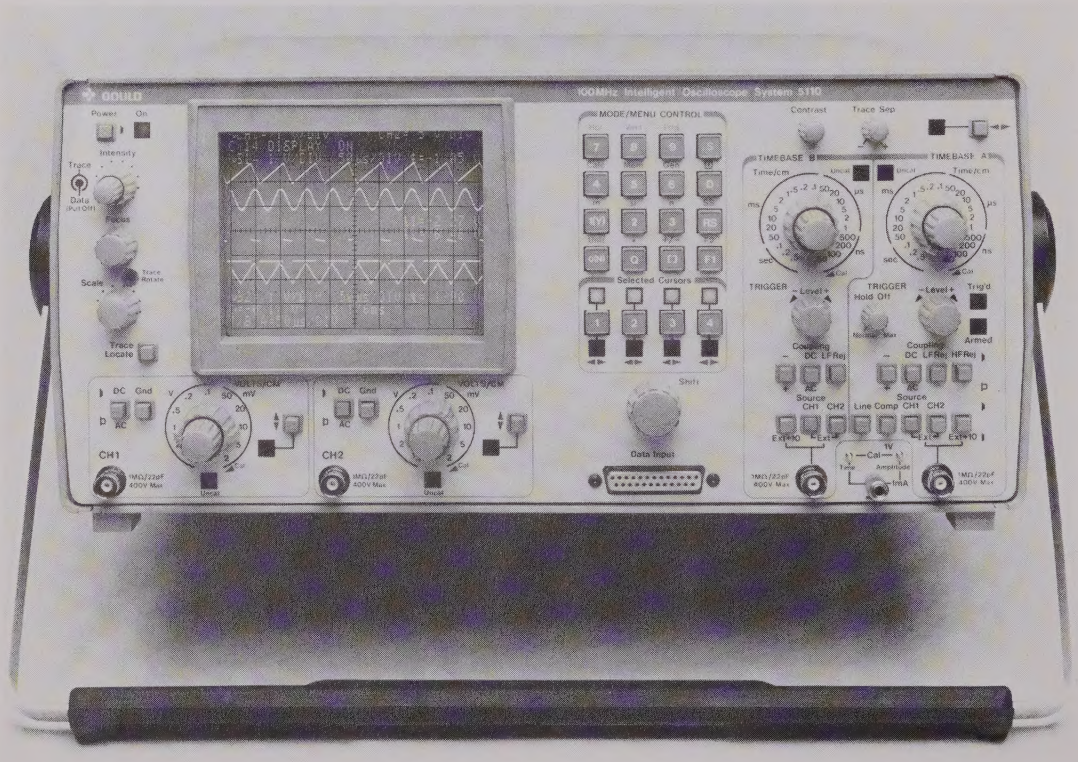


Specification

Section 2

DISPLAY

CRT 8 x 10cm rectangular.

EHT 16kV.

Graticule Internally, with 8 x 10cm divisions and 2mm sub-divisions. Independent continually variable illumination for Trace and Data.

Phosphor P31 standard.

Trace Locate Compresses trace to within graticule area.

VERTICAL DEFLECTION

Two identical input channels.

Bandwidth DC–100MHz (-3dB) DC coupled.
2Hz–100MHz (–3dB) AC coupled.

Sensitivity 2mV/cm to 5V/cm.
Uncalibrated fine gain control gives continuous adjustment between ranges with 'Uncal' warning light and symbolic indication on screen.

N.B. Bandwidth at 2mV/cm limited to 85MHz.

Accuracy ±3% in calibrated position.

Input Impedance 1M Ω/22pF.

Input Coupling AC–Ground–DC.

Maximum Input Voltage 400V DC or pk AC.

Display Modes Channel 1 only.
Channel 2 only.
Channel 1 and Channel 2 chopped (500kHz approx).
Channel 1 and Channel 2 alternate.
Channel 1 and Channel 2 added.
Trigger View, CH1 and/or CH2 alternate or chopped.
Trigger View, alternate or chopped with CH1 and CH2 added.
Channel 1 and/or Channel 2 can be inverted.
x 10 probe scaling selection for calculation mode.

HORIZONTAL DEFLECTION

Display Modes Main Timebase A.
Main Timebase A intensified by delayed Timebase B.
Delayed Timebase B.
Main Timebase A and delayed Timebase B simultaneously (alternate sweeps).
X-Y with 'A' trigger defining X deflection input source.

TIMEBASE (A)

Sweep Speeds 50ns/cm to 0.5s/cm in 22 steps (1-2-5 sequence).

Fine Sweep Control Uncalibrated. Reduces sweep rate up to 2.5 times
(slowest sweep approx. 1.25s/cm).
Warning light indicates uncalibrated condition and symbolic indication on screen.

Expansion x 10 gives max. sweep rate of 5ns/cm.

Accuracy ±3% (±5% with x 10 expansion).

DELAYED TIMEBASE (B)

Sweep Speeds 50ns/cm in 22 steps (1-2-5 sequence).

Fine Sweep Control Uncalibrated. Reduces sweep rate up to 2.5 times.
(slowest sweep approx. 1.25s/cm)
Warning light indicates uncalibrated condition and symbolic indication on screen.

Expansion x 10 gives max. sweep rate of 5ns/cm.

Accuracy ±3% (±5% with x 10 expansion).

Trace Separation Operates in A+B timebase alternate sweep mode and provides up to ±4.0cm shift on the B sweep.

Common Variable Control (Shift) Y CH1, YCH2, X and the four cursors are positioned by the common control assigned by the dedicated push button. Also control of trigger delay, trigger division ratio and phase steps.

TRIGGER

	Trigger (A)	Trigger (B)
Source	Internal CH1 Internal CH2 Composite (CH2/CH2) External External ÷ 10 Line	Internal CH1 Internal CH2 External External ÷ 10
Slope	Positive/Negative	Positive/Negative
Coupling	DC, AC, AC (If rej. AC (Hf rej.)	DC, AC, AC (If rej.)
Modes	Manual level Auto Bright Line Single shot Arm Single shot Manual Trigger Delay	Manual level Cursor Cursor + Delay Cursor + 'B' Trigger Delay Delay + 'B' Trigger Start at 'A'
Delay	Time, 10ns to 344 seconds 6 digit resolution Accuracy ±0.002% ±1 count Digital, 0–999,999,999 events	
Sensitivity	Internal To 10MHz<2mm (below 50Hz sensitivity decreases when AC coupled) 10MHz to>100MHz <1cm	Internal To 10MHz<2mm (below 50Hz sensitivity decreases when AC coupled) 10MHz to>100MHz <1cm

	External: To 10MHz at 10mV (100mV with ÷ 10 Below 50Hz sensitivity decreases when AC coupled. 10MHz to>100MHz <50mV (<0.5V with ÷ 10) Level range (internal): ±8cm. Level range (external): ±0.5V approx (±5V with ÷ 10)	External: To 10MHz at 10mV (100mV with ÷ 10 Below 50Hz sensitivity decreases when AC coupled. 10MHz to >100MHz <50mV (<0.5V with ÷ 10) Level range (internal): ±8cm Level range (external): ±0.5V approx (±5V with ÷ 10)
External Trigger	Input impedance, 1MΩ/22pF. Max.input volt. 400V (DC plus AC pk)	Input impedance, 1MΩ/22pF. Max.input volt. 400V (DC plus AC pk)

Trigger Hold-off Continuously variable up to approx one sweep length of main timebase, except for three slowest ranges.

Calibrator Voltage: 1V±1%, 1KHz approx.

Current: 1mA between 'CAL' voltage output and OV,1KHz approx.

Time: Front panel output of time is provided from an internal crystal oscillator, for calibration in the X axis, 40ns–344 secs., 6 digit resolution, min. step 20ns. Accuracy; 1 part in 10^5.

SYSTEM MEASUREMENT ACCURACY (15–35°C)

Differential measurement by centre line (single channel):
±(0.5% of reading + (0.4% of V/div. or 1 l.s.d.))

Current cursor voltage and voltage from programmed datum reference:
±(0.5% of ℄ reading + (0.5% of cursor voltage–℄ voltage) +4% of V/div. or 1 l.s.d.) after automatic zero correction

Current cursor time:
Analogue-
±(0.5% of reading + (0.1% of time/div. or 1 l.s.d))
Crystal-
For values >300μs
±(0.01% of reading + 20ns + 1 l.s.d.))

For values from 10μs–300μs
±(0.1% of reading + 1 l.s.d.)

For values <10μs
±(1% of reading + 1 l.s.d.)

Differential voltage or time and automatically calculated results, typically ±2%.
Measurements on stored waveforms, typically ±3%.

REAR PANEL

A Ramp
A timebase ramp output 2 volts peak from 50Ω source impedance

B Gate
High output for the duration of the B timebase.
TTL compatible.

Z Modulation Input
Bandwidth: DC to 10MHz.
Sensitivity: +4V from zero gives complete blanking.
Input Impedance: 2.2kΩ.

DIGITAL FACILITIES

Store size 2048 x 8 bits.

Vertical Resolution 1024 for each channel (approx 100 samples/cm).

Max. Sample Rate 1MHz (1μs/sample) reducing in proportion with timebase range.

Repetitive Sampling 1K samples stored over sequential timebase sweeps.

Real time 1K samples/channel stored in one timebase sweep.

Auxiliary store 8 sets of machine states with associated pair of stores. Scaling parameters stored with each trace. (Non-volatile).

Cursors Four cursors numbered 1–4 individually selected.
Indicated by bright up on trace, nominally 1mm horizontal width on A timebase.

DISPLAY MODES

Single or dual trace display of real time, repetitively sampled or transient storage of waveforms with alpha-numeric indication of:
–scale factors for input sensitivities and timebase
–measurement results.
or Menu selection for vertical, horizontal trigger, calculation, memory and plot mode functions.
Storage of last used settings with battery back-up.

GENERAL

Supplies 100V, 120V, 220V, 240V, 45–65Hz, 225W.

Size 184mm x 440mm x 630mm (7.25in x 17.3in x 24.8in).
176mm x 390mm x 590mm (7in x 15.35in x 23.25in excluding the handle and feet).

Weight 19.5kg (43 lbs)

Temperature Range Operating 0–50°C.
Full spec. 15–35°C.

ANALOGUE OUTPUT (Plot)

Plot Mode Menu selected start.

Y OUTPUT

An output via BNC connector selected from store 1 or store 2.

Specification

Section 2

Amplitude: 100mV per cm of screen height Bipolar output with OV corresponding to the middle of the screen.

Accuracy Output voltage per cm of display ±3%.
Output to input voltage (cal) ±3%.
± fullscale pre-setable for external cal.

Bandwidth DC–16KHz (–3dB)

X OUTPUT

X ramp via BNC connector.

Amplitude 100mV per cm of screen width.
Positive ramp resetting to OV.

Accuracy Output voltage per cm of display ±3%.
Output voltage per unit of time recorded ±3%.
Time output accuracy of Y Channel outputs ±1% (record to replay ratio).

Output impedance Output 1,2, and X ramp 100Ω/0.1μF.
Continuous short circuit protection.

Output Rate Internal clock, 50s/cm–20ms/cm.

Plot marker output TTL compatible.

Pen lift
Contacts isolated. Single contact closes from Start command to the end of read-out cycle.

Rating 50V d.c., 250mA d.c.

Isolation 50V max.

GPIB IEE–488

The optional IEEE interface printed circuit board allows the OS5100 to transmit and receive stored data, control settings and calculation results.

SH1	SOURCE HANDSHAKE – COMPLETE CAPABILITY
AH1	ACCEPTOR HANDSHAKE – COMPLETE CAPABILITY
T5	BASIC TALKER, SERIAL POLL, TALK ONLY UNADDRESS IF MLA.
TE0	EXTENDED TALKER – NO CAPABILITY.
L3	BASIC LISTENER, LISTEN ONLY, UNADDRESS IF MTA.
LE0	EXTENDED LISTENER – NO CAPABILITY.
SR1	SERVICE REQUEST – COMPLETE CAPABILITY.
RL1	REMOTE/LOCAL – COMPLETE CAPABILITY.
PP0	PARALLEL POLL – NO CAPABILITY.
DC1	DEVICE CLEAR – COMPLETE CAPABILITY.
DT1	DEVICE TRIGGER – COMPLETE CAPABILITY.
C0	CONTROLLER – NO CAPABILITY.

GENERAL

ACCESSORIES SUPPLIED

Two Probe Kits PB18
A passive Probe Kit with x 10 attenuation.
Input Impedance is 10MΩ/18pF.

OPTIONAL ACCESSORIES

Viewing Hood PN42224

Trolley TR7 General Purpose Oscilloscope Trolley.

Protective Carrying Case PN452343
A strong carrying case which completely encloses the oscilloscope with three thicknesses of padded material covering the front panel.

Rack Mount Kit PN452344

Front Panel Cover PN452121

PB100 DATA POD (Optional)

INPUTS

Number Eight signals and two qualifiers.

Impedance 50KΩ, 8 pF nominal.

Threshold Fixed TTL (÷1.4V) and ECL (–1.3V), adjustable approximately ±12V nominal. Test point measurement of one tenth actual level.

Minimum Pulsewidth 10nsec at 500 mV threshold overdrive.

Maximum Voltage ±25V continuous.

CLOCK

Input Via Q1 or Q2, same electrical specification as data inputs above. One input may be the clock and the other a qualifier. Logic sense switches provided.

Output Via BNC cable. Bipolar signal: ZERO level–1.7V; ONE level +2V nominal.

TRIGGER

Source Via eight switches: 1,X (Don't care), and 0. For the time period that the input signals satisfy the combination selected, a positive level (+2V) is output.

Qualifiers Q1 and Q2 may be used to qualify the 8 bit parallel word.

Output Via BNC cable, TTL level. LED indicator blinks on for 0.5 sec when trigger occurs.

Response in FAST position, combination must be true for 20nsec minimum. In SLOW position, combination must be true for 180±25nsec.

DATA OUTPUTS

Provision Via cable with D type connector.

Levels ZERO, 0.4V, ONE, 3.4V nominal.
Noninverting with respect to input signals.

MISCELLANEOUS

Temperature Range Operating, 0 to 50°C.

Power ±5V at 360 mA, –5V at 100mA.
(Supplied from the OS5100).

Size 3.6 in. (9.2cm) wide, 6.8 in. (17.3Cm) deep, 1 in. (2.5 cm) thick; 1 lb (0.5 kg) weight.

3.1 INTRODUCTION

The 5110 has all the analogue controls and facilities of a conventional dual trace oscilloscope, but backed up by a sophisticated software system controlled by a front panel keypad (MODE/MENU CONTROL). This software system provides for the display of alphanumeric data (eg timebase and amplifier settings etc) with the traces, and also a large number of menu pages for the selection of various operational modes. Therefore, because of the instrument's versatility and complexity it is assumed that the reader is conversant with the use of modern oscilloscopes, and hence this section is concerned mainly with the use of the keypad and the menus to obtain the operational modes.

An internal nickel-cadmium battery provides a "keep-alive" voltage for the RAM stores so that when the instrument is switched on it will always start up in the operational mode that it was in when switched off. This is known as the "warm start" facility. In the event of the instrument not having been used previously (ie on receipt from the manufacturer) or the nickel-cadmium battery being completely discharged (ie the instrument having been left unused for more than 9 months), the software carries out a "cold start" procedure on switching on. This, however, can be considered as an unusual situation and as such is described elsewhere in this section (section 3.22). In general, therefore, the "warm start" can be assumed to be the normal start up procedure.

The following sections discuss, first, the basic switching on procedure and then the conventional amplifier, timebase and shift controls, the use of the keypad, and finally, the interpretation of the menu pages and the selection of the operational modes.

NOTE: The expression "default" used in this publication and appearing on displays refers to the state of specifiable operating modes. Any mode that has not been specified by the operator is specified instead by the instrument software, this being known as the default setting.

SAFETY

This instruction manual contains information and warnings which must be observed by the user to ensure safe operation and retain the apparatus in a safe condition. The instrument has been designed to operate indoors, within the specified limits of temperature. It should not be switched on if there are obvious signs of mechanical damage and it should not be used under wet conditions.

EARTHING

The instrument must be operated with a protective earth connected via the appropriate (yellow/green) conductor of the supply cable. This is connected to the instrument before the line and neutral supply connections when the supply socket is inserted into the plug on the back of the instrument. If the final connection between the instrument and the supply is made elsewhere, the user must ensure that the earth connection is made before line and neutral.

If any supply cable other than that supplied with the instrument is used, it must carry an adequate protective earth conductor.

WARNING

Any interruption of the protective earth conductor inside or outside the instrument is likely to make the instrument dangerous. Intentional interruption is prohibited.

Signal connections into the instrument should be connected after and disconnected before the protective earth connection is made, i.e. the supply lead must be connected at all times that signal leads are connected.

LIVE PARTS

The instrument is safe to operate with the covers fitted and these must not be removed under normal usage. The covers protect the user from live parts and they should be removed only by suitably qualified personnel for maintenance or repair purposes. (see maintenance section).

3.2 SAFETY AND SWITCHING ON

CAUTION: The 5110 has an integral blower motor to provide forced air cooling and must always be operated in a position such that there is no restriction to the air entering through the louvres around the unit case and exiting at the rear.

1. Set the support/carrying handle to the required operating position. The handle is released by pulling both fixing bushes outward, and can then be turned to lock in any of five positions.
2. Before connecting the 5110 to the mains supply, check that the supply range switches are set to suit that supply voltage to be used and that the correct fuse is fitted. Note that the fuse has to be changed when switching between the 100V and 220V ranges. The switches and fuse holder are mounted on the back panel of the instrument. Do not operate the supply selection switches while the instrument is switched on.
3. Push the POWER button and ensure that the ON lamp lights. An alphanumeric display should be obtained within 15 seconds and full calibrated performance within 20 minutes.
4. If necessary, adjust the FOCUS and DATA (inner) INTENSITY controls to obtain a clear display, and the SCALE control to illuminate the graticule.

3.3 Y CHANNELS OPERATION

A similar set of controls are provided for each of the Y channels, CH1 and CH2.

1. A locking push button is provided for selecting DC/AC input.

(a) For direct coupling of the input signal, select DC (button in).

(b) For coupling via the internal 0.1μF capacitor, select AC (button out).

2. Two controls are provided for deflection sensitivity.

(a) Adjust the VOLTS/CM switch to obtain the required vertical deflection.

(b) The variable VOLTS/CM control fitted concentrically with the switch provides continuous variation of sensitivity between the stepped ranges. When the variable control is turned in an anticlockwise direction from its CAL position, a red warning light (UNCAL) illuminates to show that the deflection sensitivity is no longer calibrated.

3. To locate the ground or zero volts level, operate the GND push button. This open circuits the input signal and connects the amplifier input to ground.

4. Either CH1 or CH2 can be removed from the display by operating the blue (S) push button on the keypad and the ▲▼ shift push button in sequence. The channel is restored to the display simply by pressing the ▲▼ push button a second time.

3.4 A TIMEBASE OPERATION

The speed of the A timebase is determined by the setting of the A TIME/CM switch. A variable TIME/CM control is fitted concentrically with the switch and provides a further 3:1 (approx.) variation. When the variable control is turned in an anticlockwise direction from its switched CAL position, a red warning light (UNCAL) illuminates to show that the A timebase is no longer calibrated.

The timebase setting is indicated at the bottom of the Alpha-Numeric display. When the UNCAL is operated, a > symbol is used and a := is used to indicate that the X10 scaling has modified the value.

NOTE: Any misalignment of the trace with the horizontal lines on the graticule should be corrected by adjusting the TRACE ROTATE preset control.

The CONTRAST control adjusts the contrast between the A timebase and the brightened part of the A timebase (ie that part of the trace selected for display on the B timebase).

3.5 A TIMEBASE TRIGGER

1. The A timebase may be triggered by the following sources as selected by the SOURCE locking push buttons.

(a) CH1 or CH2 selects the output of the appropriate amplifier.

(b) COMP (composite) selects a mixture of CH1 and CH2 signals such that each channel may produce a stable trace.

(c) LINE: the power supply line input frequency derived internally from the supply transformer.

(d) EXT: an external triggering source connected to the associated socket is selected when CH1 and CH2 are selected simultaneously. The sensitivity of this external input can be reduced 10 times by the additional operation of the EXT÷10 push button.

2. The LEVEL control allows the selection of the triggering point on the trigger waveform and hence the determination of the start of the horizontal trace.

3. If required, the COUPLING locking push buttons are used in conjunction with the SOURCE push buttons to connect different networks into the trigger amplifier circuit.

(a) Negative/positive (marked – +) determines whether triggering occurs as the input signal passes the selected trigger level in a negative or positive-going direction. This allows the amplifier to trigger on negative-going leading edges (button in), or on positive-going leading edges (button out).

(b) DC/AC input. AC (button out) coupling is useful for wideband trigger on most signals. The DC position (button in) is also a wideband trigger mode but is most useful at very low frequencies or when the mark-space ratio of a pulse signal is likely to wary. The Y input coupling (section 3.3) must also be set to DC for this mode to be effective on internal trigger.

(c) LF REJ (button in) switches a filter into circuit to reject low frequencies. This allows stable triggering on the high frequency component of complex waveforms by rejecting the lower frequency component(s). Note that this switch automatically reverts the trigger amplifier to an ac coupled mode even if dc trigger has been selected.

(d) HF REJ (button in) switches a dc coupled filter into circuit to reject high frequencies. This allows low frequency triggering to be effected from complex waveforms containing high frequency components. The cross-over frequency of both the hf and the lf filters is approximately 10kHz.

3.5.1 TRIGGER HOLD-OFF

When the HOLD OFF control is in its normal (fully anticlockwise) position, the hold-off circuit provides sufficient delay for the timebase to recover before the start of the next sweep. When used as a variable control its main function is to provide effective triggering on some complex waveforms.

In most positions of the timebase range switch, the

range of hold-off variation is about equivalent to the time taken for the timebase to complete one sweep. In the case where the timebase is required to be triggered on a complex waveform (eg a repetitive logic pulse pattern containing pulses of different widths), the HOLD OFF control may be used to inhibit triggering until the desired period in the waveform is reached.

NOTE: When triggering at high frequency, any slight jitter visible on the trace may be removed by fine adjustment of the HOLD OFF control.

3.6 B TIMEBASE OPERATION AND TRIGGER

The speed of the B timebase is determined by the setting of the B TIME/CM switch which, with its uncalibrated variable control, has the same ranges as the A TIME/CM switch (section 3.4). The TRACE SEP control offsets the B timebase with respect to the A.

The B trigger source selection is similar to that of the A timebase (section 3.5) but does not incorporate COMP or LINE trigger. The trigger coupling facilities are also similar to those of the A timebase but without the HF REJ push button.

There is no hold-off facility for the B timebase trigger.

3.7 SHIFT CONTROL

The single, general purpose, SHIFT control is used for CH1 and CH2 Y shift, X shift and cursor shift. Unless it has previously been allocated by the system software for some other function, the control is selected for a shift function simply by operating the appropriate push button, eg pressing the ◄► push button provides the X shift facility. Similarly, pressing the CH1 or CH2 ▲▼ push button allows it to be used for Y shift on that channel, and the SELECTED CURSORS push buttons allow it to be used for moving a particular cursor along in associated trace.

The allocation of the SHIFT control for a particular purpose is indicated by the illumination of the associated green indicator light. The deselection of the control is achieved either by operating the push button a second time (they are a non-locking press on, press off type), or when it is selected for another purpose.

3.8 CURSORS

Four cursors, C1 to C4, are available on the display for voltage and time measurement purposes and appear as brightened spots, or sections, on the trace. Measurements are made at the leading (ie left hand) edge of a cursor.

Cursors are selected individually by operating the SELECTED CURSORS push buttons, and their presence is indicated by the illumination of the associated indicator light situated above the push button. A cursor may be removed from the display by operating the blue (S) push button on the keypad and its SELECTED CURSORS push button in sequence. It is restored to the display simply by pressing its push button a second time which would also result in it being attached to the SHIFT control (section 3.7).

The current cursor referred to in the alphanumeric data appearing on the display is that cursor attached to the SHIFT control (section 3.7) or the last cursor selected. Unless a calculation is being performed (section 3.15), current cursor time and voltage information is displayed on line 15 of a mixed display. Cursors associated with store traces always flash. Real time trace cursors can also be caused to flash by holding their SELECTED CURSORS push button pressed (this is useful for identifying a particular cursor when there is more than one appearing on the display).

The allocation of cursors to channels (CH1 and CH2), timebases (A and B) and stores (ST1 and ST2) follows a set of rules and priorities.

(a) In general, cursors are allocated to channels in the order C1 and C2 to CH1, and C3 and C4 to CH2.

(b) Similarly, the general rule for the allocation to timebases is that C1 and C3 appear on timebase A, and C2 and C4 on timebase B.

(c) If only one channel is selected, all four cursors are allocated to that channel.

(d) If only timebase A is selected, all four cursors appear on that timebase.

(e) If only timebase B is selected, only C2 and C4 appear on the display. C1 and C3 cannot be made to appear on timebase B.

(f) If the contents of either store (ST1 or ST2) are displayed, then C1 and C3 are allocated to that store and are removed from whatever real time trace they may have been previously allocated to. Cursors C2 and C4 remain allocated to their associated real time traces.

(g) If the contents of both ST1 and ST2 are displayed, then C1 and C2 are allocated to ST1, and C3 and C4 to ST2. No cursors then appear on any real time trace on the display.

3.9 MODE/MENU CONTROL KEYPAD

The fourteen MODE/MENU CONTROL push buttons are allocated as follows:

(a) Ten push buttons, coded 0 to 9, are used for inputting numeric data as instructed by the menu pages. Two of the push buttons (1 and 0) also serve for inputting "yes" (Y) and "no" (N).

(b) The blue S, or second function, push button has no direct effect on its own, but modifies the function of the next push button to be operated. If this is one of the ten numeric push

buttons mentioned above, then it takes on the function referred to in the annotation above it, eg by pressing S7 the HOR (horizontal) menu page is displayed. As discussed previously (sections 3.3 and 3.8) the S push button is also used in conjunction with the appropriate shift push button for deselecting a channel or a cursor.

(c) The Q, or quit, push button provides an abort facility in that it takes the display down one level of information. In this respect, examining a trace is considered as the lowest level. In effect, pressing Q stops the operation in process and restores the display to the previous state.

(d) The [ ] push button can be dedicated to a particular function by a menu and is indicated as such on the display. Otherwise (in the default condition) it may be used for stepping pages within a menu in a continuous manner. All menus consist of at least two pages and always return to page 1 after the final page. This button is also used when viewing a mixed display for reading a menu page (see para. 6 in section 3.10.2).

(e) The D, or dual option, push button allows instant switching between two pre-selected options for a particular mode while setting up another mode (section 3.17).

NOTE: Wherever it appears in this section or on the displayed menu pages, the instruction "key" followed by one or two alphanumerics implies that those keypad push buttons are to be operated sequentially.

NOTE: If at any time an invalid code is keyed in, a statement to that effect, together with an explanation if applicable, appears on the display between two rows of asterisks.

3.10 WARM START

As stated in section 3.1, the 5110 normally starts up in the operational mode that it was in when switched off. Therefore, the alphanumeric display obtained after the initial 15 seconds warm-up period consists of page 1 of Current Control Settings (Fig. 3.3). This, together with the subsequent page 2 (obtained by keying 30 or [ ]), details the software-controlled operational modes. The timebase speed, and the Y amplifier sensitivities are, of course, controlled manually by the rotary switches (sections 3.3 and 3.4).

However, for the purposes of operator instruction we will start by considering the General Mode Index page (fig. 3.2). This is obtained after the appearance of the Current Control Settings page 1 by keying 00, or at any time by keying S6.

3.10.1 GENERAL MODE INDEX

Having obtained the General Mode Index, any of the seven pages listed can be obtained simply by keying the appropriate option number. Alternatively, the [ ] push button may be used for stepping through the pages consecutively.

(a) Key 10 to obtain general operating information and advice.

(b) Key 20 and 30 for Current Control Settings data. In addition to detailing the current settings, these pages also list the key selections for obtaining the Horizontal Mode menu (key S7), the Vertical Mode menu (key S8), the Memory Mode menu (key S5), the Trigger Mode menu (key S9) and the Calculation Mode menu (key S4).

(c) Key 40 for Default Control Setting data. These are the control settings that would exist in the absence of any alternative stored settings. As in the case of Current Control Settings, key selections are listed for obtaining the relevant menus.

(d) Key 50 for the Software Calibration menu.

(e) Key 60 for the Dual Option menu.

(f) Key 70 for the Self Test menu.

(g) Key 80 for the Measurement/Calibration menu.

3.10.2 OBTAINING A TRACE

1. Press the Q push button. The selected trace(s) should appear together with the relevant control setting data (Fig. 3.1). This is referred to as a mixed display.

2. If necessary, operate the TRACE LOCATE push button and adjust the X and Y shift settings (section 3.7) to centralise the horizontal trace (timebase triggered) or spot (timebase not triggered, or X-Y selected for the horizontal mode).

   Active TRACE LOCATE is selected by operating the trace location button at the same time operating the channel ▲▼ button. The cursor on the trace is set to the centre line automatically correcting the values on the screen.

3. Adjust the TRACE (outer) INTENSITY control to obtain a clear display.

4. If both A and B timebases are being displayed, adjust TRACE SEP to separate them.

5. If the A intensified by B or A and B alternate horizontal mode has been selected, adjust CONTRAST to obtain a suitable contrast between the A timebase and the brightened part of that timebase.

6. If required, hold the [ ] push button depressed to read the menu page used immediately prior to pressing Q. Part of the data accompanying the

trace is a line detailing this menu (Fig. 3.1).

7. If required, pull the DATA INTENSITY knob outwards to remove the alphanumeric data from the mixed display.

3.11 HORIZONTAL MODE SETTING

1. Key S7 to obtain the Horizontal Mode menu page 1.
2. The current selection will be shown on the right and there are five possible options.
   (a) A timebase only (key 01).
   (b) A timebase intensified by B (key 02). In this case no B timebase appears, but that part of the A timebase selected for eventual display on the B trace is brightened. Initially, the B TIME/CM switch should be set 2 or 3 ranges faster than the A TIME/CM switch.
   (c) B timebase only (key 03).
   (d) A and B alternate (key 04). This mode provides simultaneous display of the A intensified by B and the B traces by switching the beam between the A and B timebase signals on alternate timebase cycles.
   (e) X-Y mode (key 05). The selection of this mode disables the timebase and the X deflection is derived from the selected A trigger signal. (Refer to section 3.20).
3. Key 06 to switch the B1 facility on or off. With this switched on the start of the B sweep is modified by the setting of the cursor C1.
4. Key 07 to switch the B3 facility on or off. With this switched on the start of the B sweep is modified by the setting of the cursor C3.

NOTE: Options 06 and 07 are available only in certain trigger modes (see section 3.13.2). If the appropriate trigger mode has not been selected then the legend "B SWEEP NOT MODIFIED BY CURSOR" appears on the Horizontal Mode menu page 1 instead of options 06 and 07.

5. Key 10 or [ ] to obtain the next page of the menu.
6. Key 11 to switch the x10 expansion on or off. This option is not operative when the X-Y mode is selected.
7. Key 12 to switch the X tracks cursor facility on or off. This is available only when the x10 expansion is switched on. When shifting a cursor along an expanded trace it causes the trace to move at the same rate and in the opposite direction as the cursor so that the cursor remains in the same position on the display. This overcomes the difficulty normally encountered in positioning a cursor at a particular point on an expanded trace.
8. After pressing the Q push button to obtain the mixed display (section 3.10.2), further amendments can be made to the horizontal mode if required by keying in the options discussed above.

3.12 VERTICAL MODE SETTING

1. Key S8 to obtain the Vertical Mode menu page 1.
2. The current selection will be shown on the right and there are six possible options.
   (a) CH1 only (key 01).
   (b) CH2 only (key 02).
   (c) Dual auto (key 03). This enables CH1 and CH2 signals to be displayed simultaneously, with the instrument software making the selection between the chop or alternate modes of beam switching. In order to force the instrument into either the chop or alternate modes of dual display then either option 04 or 05 should be selected.
   (d) Dual display with the chop mode of beam switching (key 04). This should be selected if the timebase speed is slower than about 1ms/cm.
   (e) Dual Display with the alternate mode of beam switching (key 05). This should be selected if the timebase speed is faster than about 1ms/cm.
   (f) Add CH1 and CH2 (key 06). This enables the CH1 and CH2 signals to be added algebraically onto a single trace. Waveform subtraction can be achieved by means of invert options 07 and 08.
3. Key 07 to switch the invert CH1 facility on or off.
4. Key 08 to switch the invert CH2 facility on or off.
5. Key 09 to switch the trigger view facility on or off. Whatever vertical mode has been selected, switching this on will produce another trace showing the signal in the A trigger amplifier. This facility, however, is automatically disabled if composite trigger (section 3.5) has been selected, and the display of trigger view only (ie no other Y signals displayed) is not possible. The trigger view trace has three main functions.
   (a) It gives a guide to trigger level. When viewing CH1 or CH2, the sensitivity of the trigger view display is approximately that which is selected on the Y channel VOLTS/CM switch.
   (b) It enables the effectiveness of the LF REJ and HF REJ filters to be observed.
   (c) It enables a third Y channel to be available via the EXT A input socket when EXT trigger source is selected. In this case the sensitivity is approximately 50mV/cm (500mV/cm with EXT÷10 selected).
6. Key 10 or [ ] to obtain the next page of the menu.

7. Key 11 to indicate whether or not a x10 probe is being used on the CH1 input. This will cause all measurements to be scaled accordingly.
8. Key 12 to indicate whether or not a x10 probe is being used on the CH2 input. This will cause all measurements to be scaled accordingly.
9. After pressing the Q push button to obtain the mixed display (section 3.10.2), further amendments can be made to the vertical mode if required by keying in the options discussed above.

3.13 TRIGGER MODE SETTING

Trigger selection is a more detailed procedure than horizontal and vertical selection (sections 3.11 and 3.12) in that in addition to the Trigger Mode menu page (key 00), there is a Qualification menu page (key 10), and three Delay System menu pages (key 20, 30, 40).

Two front panel indicator lights are associated with the trigger circuits.

(a) TRIG'D. This lights to indicate that a trigger waveform is present at the A trigger amplifier, and therefore that the timebase is being triggered. This will be found useful when examining complex waveforms in that it will confirm that correct triggering is taking place.

(b) ARMED. This lights in the single shot mode (option 03) to indicate that the timebase is ready to be triggered.

3.13.1 MODE SELECTION

1. Key S9 to obtain the Trigger Mode menu.
2. The current selection will be shown on the right and there are four possible options.

(a) Normal (key 01). In this mode the trace will blank in the absence of a trigger signal.

(b) Auto (key 02). In this mode the timebase will free-run and display a bright line or unsynchronised display in the absence of a correct trigger signal. This helps in finding the trace initially. When the TRIGGER LEVEL control is adjusted and/or the amplitude of the trigger signal is increased to obtain effective triggering, the timebase will revert automatically to normal triggering as in (a) above. The auto mode is useful for wideband signals above 40Hz, but operation below this frequency may cause mis-triggering since the timebase can revert periodically to its free-run state.

(c) Single shot (key 03). In this mode the [ ] push button is dedicated to the timebase arming function, as indicated by the legend [ARM] on the menu page. Once the timebase has been armed by pressing the [ ] push button, indicated by the illumination of the ARMED light, the timebase operates and provides a single sweep only upon receipt of the next trigger signal. To initiate further sweeps it is necessary to re-arm the timebase by pressing the [ ] push button again.

(d) Single shot manual (key 04). In this mode the [ ] push button is dedicated to the timebase triggering function, as indicated by the legend [TRIG] on the menu page. The timebase operates and provides a single sweep every time the [ ] button is pressed.

3.13.2 MODE QUALIFICATION

1. Having made the preliminary mode selection (section 3.13.1), key 10 to obtain the Qualification menu. This provides two options for the start of timebase A (options 11 and 12) and seven options for the start of timebase B (options 13 to 19).
2. Select the start of timebase A:

(a) Key 11 for the sweep to be started by the A trigger source.

(b) Key 12 for the sweep to be started by the delay system. In this case it will be necessary to carry out a selection on the Delay System menu – refer to section 3.13.3.

NOTE: The delay system cannot be used for starting timebase A if it has already been selected for timebase B (options 15, 16, 19), and vice versa.

3. Select the start of timebase B:

(a) Key 13 for the sweep to be started by the appropriate cursor (see section 3.8).

(b) Key 14 for the sweep to be started by the first B trigger signal occuring after the appropriate cursor.

(c) Key 15 for the sweep to be started by the delay system.

(d) Key 16 for the sweep to be started by the first B trigger signal occuring after a delay controlled by the delay system.

(e) Key 17 for the sweep to be started by the B trigger source.

(f) Key 18 for the sweep start to be coincident with the A sweep start.

(g) Key 19 for the sweep to be started by the appropriate cursor after a delay controlled by the delay system.

NOTE: In the case of options 15, 16 and 19 it will be

necessary to carry out a selection on the Delay System menu – refer to section 3.13.3.

3.13.3 DELAY SYSTEM

1. If the delay system is to be applied to timebase A (ie option 12 selected), key 20 to obtain the first page of the Delay System menu. There are two possible methods for defining the A sweep delay, either "A START DELAYED FROM A TRIGGER" to a particular time or event, or "A STARTS" after a particular number of events or period of time.
   (a) Key 21 for the sweep to start time T after the A trigger.
   (b) Key 22 for the sweep to start on the Nth B trigger after the A trigger.
   (c) Key 23 for the sweep to start on every Nth A trigger (÷N mode).
   (d) Key 24 for the sweep to start every Nx10ns. In this case the sweep is no longer synchronised to the A trigger, but instead is in effect triggered from a free running internal timer/counter.

NOTE: For each of the above options it will be necessary to define a further parameter, either time T or integer N. Refer to para. 5 below.

2. If the delay system is to be applied to timebase B (ie option 15, 16 or 19), key 30 to obtain the second page of the Delay System menu. The delay period is defined by specifying the start, for which there are six options (31 to 36), and the end, for which there are three options (37, 38, 39).
3. Specify the delay period start time:
   (a) Key 31 for the start of the A sweep.
   (b) Key 32 for the B trigger.
   (c) Key 33 for the appropriate cursor.
   (d) Key 34 for the first B trigger signal occuring after the appropriate cursor.
   (e) Key 35 for the A trigger.
   (f) Key 36 for the first A trigger signal occuring after the appropriate cursor.

NOTE: If either option 16 or 19 was selected in section 3.13.2, then options 31 and 33 only are available for specifying the delay period start time.

4. Specify the delay period end time:
   (a) Key 37 for time T.
   (b) Key 38 for the Nth B trigger signal.
   (c) Key 39 for the next event in the Nth B trigger sequence (÷N mode). In this case the start time (options 31 to 36) is irrelevant, the B sweep starts on or after every Nth B trigger.

NOTE: As in the case of the A timebase, for each of the above three options it will be necessary to define a further parameter, either time T or integer N. Refer to para. 5 below.

5. Key 40 to obtain the final page of the Delay System menu. This shows the current selection of T (time), N (events) and S (increment/decrement steps). It will be seen from this page that further options (44 to 47) are available for modifying T or N while observing the trace.

NOTE: When specifying T, N and S in options 41, 42 and 43, the [ ] push button has a "cancel last entry" function. With each of these options, having specified the value and units, the question "IS THIS TRUE VALUE Y/N?" appears at the foot of the menu page. This must be answered by keying (Y), in which case the specified value appears as the current selection, or (N), in which case the value keyed in is deleted and a new value can be specified.

6. To specify a time value for T, key 41. Use the numeric push buttons to specify the quantity, keying SQ for decimal point if required, followed by the units: S0 for seconds, S1 for milliseconds, S2 for microseconds or S3 for nanoseconds.
7. To specify an event number for N, key 42. Use the numeric push buttons to specify a whole number quantity followed by S0 for units.
8. Option 44 allows incremental (keying 1) or decremental (keying 0) stepping of T, or N, while observing the trace(s). The size of the steps is determined by the step value S. To specify S, key 43. If the current selection is "TIME", then S is specified as a time as in the case of T, but if the current selection is "EVENTS", then S is specified as a whole number as in the case of N.
9. Option 46 allows T, or N, to be incremented or decremented by means of the SHIFT control while observing the trace(s), the rate being dependent on the value of S, ie a high value produces a coarse control and a low value a fine control.
10. Options 45 and 47 can be used only with options 23, 24 and 39 (ie where the end of the delay is dependent on N), and provide a means of moving to a point of interest on a waveform by incrementing or decrementing the value of N for one sweep. If N is a low value, Key 45 and use the 1 and 0 push buttons (as in the case of option 44), but if N is large, key 47 and use the SHIFT control.
11. Holding the 1 or 0 key for a time brings the auto keyboard repeat function into operation which after adding continuously increments or decrements, the daley value by the preset steps. The operation stops immediately the appropriate key is released.

3.14 MEMORY MODE SETTING

1. Key S5 to obtain the Memory Mode menu.
2. Key 01 to switch on or off the display of ST1 contents.
3. Key 02 to switch on or off the display of ST2 contents.
4. Press the Q push button to display the trace(s). Alphanumeric data relevant to the stored waveforms at the time of their capture will appear on the display.

3.14.1 CAPTURE SELECTION

There are two methods of capturing and storing a waveform – realtime and repetitive.

In the case of real time capture, as the incoming waveform arrives at the instrument, voltage samples are taken at regular intervals and placed in store. Thus it is possible to capture a transient waveform or a one-shot event. The pre-trigger option (see para. 6 below) makes it possible to also capture events prior to the waveform trigger.

At high sweep rates, however, it is not possible to capture a waveform in this manner. Instead, one voltage sample only is taken on each sweep with the sample point moving with respect to the trigger point between sweeps. This is known as repetitive capture and extends the capture range to 100MHz, but it is not possible to capture transient events.

1. Key 10 to obtain the first page of Capture menu. This and the subsequent page (key 20) detail the options for selecting the waveform to be captured, where it is to be stored, and how it is to be captured.
2. Select the source.
   (a) CH1 (key 11).
   (b) CH2 (key 12).
   (c) Dual (key 13).
3. Select the sweep to be captured.
   (a) A sweep (key 14).
   (b) B/B1 sweep (key 15). As B and B1 are mutually exclusive there can be no confusion.
   (c) B3 sweep (key 16).

NOTE: In the event of an invalid selection being made (eg attempting to select CH2 for capture when CH1 has been selected for the vertical mode setting), an asterisk will appear alongside the current selection.

4. Select the destination store.
   (a) ST1 (key 17).
   (b) ST2 (key 18).
5. Key 20 to obtain the second page of the Capture menu. If the timebase range of the waveform to be captured is within the limits 50μs/cm, it is possible to select either repetitive capture (key 21), or real-time capture (key 22) with reduced resolution. No operator choice is available outside this timebase range, the internal software makes the appropriate choice.
6. If real-time capture has been selected (either by the operator or by the software) it is possible for either 0% (key 23) or 50% (key 24) of the captured waveform to be pre-trigger. However, this facility is available on the A sweep only.
7. The input signal can be averaged to reduce noise. In realtime capture, the number of sweeps can be defined with the resultant average displayed. In 'repetitive' capture, each point can be progressively captured over a preset number of sweeps, displaying the resultant average. To set the number of captures to be averaged (key 25). The displayed number of averages will flash to indicate it is ready to be changed. The number of averages is incremented in powers of 2 by keying 1 and decremented by keying 0, e.g. 0, 2, 4, 8 . . . . 256. The maximum number is 256. Press Q to return to the menu.
8. Key 19 to return to a mixed display and then press the [ ] push button to start the capture.

3.14.2 PLOTTER SELECTION

Key 30 and 40 to obtain pages 1 and 2 respectively of the Plotter menu.

The purpose of the plotter output facility is to provide a hardcopy printout on X-Y or T-Y type plotters of the contents of ST1 and ST2. The single output can be assigned to either Store 1 or Store 2 by keying 81 or 32. The output rate can be set in the range 50sec/div to 10ms/div. by keying 37 and inputting the desired rate via the key pad. Keying 38 starts the output, the X ramp being synchronised to the selected plot rate. The plot can be aborted at any time by keying 39.

To assist in setting the correct operating range for the recorder, the full scale outputs for X (1.024V), +Y (+400mV) and −Y (−400mV) can be set. Note the display centre line corresponds to 0V output. The warning bell to indicate the finish of a plot cycle is available by keying 45.

3.14.3 MACHINE STATE STORAGE

GENERAL

The machine state is comprised of three sections:–

1. The selections made from all menus.
2. The settings of the manual controls.
   CH1, 2 Volts/cm + UNCAL
   TBA, B Time/cm, + UNCAL
   CH1, 2 AC/DC/GND
3. The contents of store 1 & store 2.

At the simplest level, section 1 is preserved during switch off.

OPERATION OF SS (SAVE SWITCH)

Operating SS (second function RS) instructs the instrument to save the current machine state in one of the eight machine state storage areas. These areas are non-volatile and are referred to by their index number 1 through 8.

The operator will be asked to specify the index number and also whether manual controls are to be included. (see RS paragraph for more details about manual controls Section 1 & 3 will be stored automatically.

Note that only alternate locations of each store are saved enabling a pair of stores to be contained in a 1K byte segment. This is referred to as a machine state store (MSS).

OPERATION OF RS (RECALL STATE)

Operating RS instructs the instrument to change the state of the instrument to match that of the stored one.

Again the operator must supply the index number.

Section 1 & 3 are recalled without the intervention of the operator. When section 2 is recalled, the operator will be prompted to adjust the manual controls as appropriate. As this procedure can be lengthy, the operator is given the choice of saving the machine state without section 2. The operator can press Q (Quit) to avoid having to change the manual control.

NOTES:

a) The calibration of the instrument is NOT affected by machine state save/recall.

b) One fixed machine state is included, index number 0, which will 'normalise' the instrument to the settings shown on General Mode option 40 and has the same effect as operating General Mode option 41 with less key presses. Note that machine state zero (MS0) contains only section 1.

3.15 CALCULATION MODE SETTING

To carry out time and voltage measurements, key S4 to obtain the Calculation Mode index page. This mode provides a selection of options to enable a variety of accurate time and voltage measurements and event counts to be made in conjunction with the cursors (section 3.8). The result of any measurements appears on line 15 of a mixed display (Fig. 3.1).

All measurements are made at the leading (ie left hand) edge of a cursor and are taken with respect to ground (0V) and the start of the A or B timebase as appropriate. The displayed values only may be modified as described in the following paragraphs. Current cursor calculations take place when no other specific calculations are requested (section 3.15.3).

3.15.1 X PARAMETER MEASUREMENT

The measurement taken at a cursor has two parameters: voltage and time (or events). The latter is referred to as the X parameter, being measurement along the X-axis of the display.

1. Key 10 for the first page of the menu. Either time or the number of B trigger events can be measured up to a particular cursor.
   (a) Auto-time (key 11). This uses either the sweep ramp waveform to make an analogue measurement which is converted to a 3-digit time readout, or alternatively uses the internal timer/counter if it has not been allocated for any other purpose. If the timer is being used for the measurement, then the legend X appears on line 15 of the mixed display.
   (b) Xtal-time (key 12). This uses the internal timer/counter to give a digit time readout accompanied by the legend X on line 15.
   (c) B trigger events (key 13). This also uses the internal timer/counter to give an events count readout of up to 9 digits accompanied by the legend E on line 15.

NOTE: Options 12 and 13 are not available if the internal timer/counter has already been allocated for any other purpose.

2. The X parameter measurement is assumed to start from the start of timebase A. However, if the cursor in question is on a B sweep, the horizontal datum can be specified if required. Key 30 for the third page of the menu:
   (a) Datum = A start (key 34).
   (b) Datum = B start (key 35).
   (c) Datum = auto (key 36). In this case the datum is the start of timebase A if it is viewed, otherwise it is the start of timebase B.

NOTE: The legend A or B appears on line 15 to indicate the horizontal datum (Fig. 3.1).

3.15.2 USER DATUM SELECTION

The instrument internal datum for any measurement is zero (volts, time or events). If required the operator may set in his own datum in which case the legend U appears on line 15 of the mixed display.

1. Key 20 to obtain the second page of the menu. This shows the current user datum selections for the four cursors.
2. Key 21 to switch the user datums on or off. When switched on, the legend "(TIME)" or "(EVENTS)" appears on this line of the menu to indicate which was selected for the X parameter measurement (section 3.15.1).

NOTE: When specifying voltage, time and events in options 22, 23 and 24, the [ ] push button has a "cancel last entry" function. With each of these options, having specified the value and units, the question "IS THIS TRUE VALUE Y/N?" appears at the foot of the menu page. This must be answered by keying (Y),

in which case the specified value appears as the current selection, or (N), in which case the value keyed in is deleted and a new value can be specified.

3. To specify a user datum for voltage, key 22. The legend "CURSOR 1, 2, 3, 4" must be answered by keying in one cursor number. Use the numeric push buttons to specify the voltage, keying SQ for decimal point if required, followed by S0 for volts or S1 for millivolts.

4. To specify a user datum for time, key 23. The legend 'CURSOR 1, 2, 3, 4" must be answered by keying in one cursor number. Use the numeric push buttons to specify the time, keying SQ for decimal point if required, followed by the units: S0 for seconds, S1 for milliseconds, S2 for microseconds or S3 for nanoseconds.

5. To specify a user datum for events, key 24. The legend "CURSOR 1, 2, 3, 4" must be answered by keying in one cursor number. Use the numeric push buttons to specify a whole number quantity followed by S0 for units.

An alternative method of specifying user datums is by transferring from the current cursor's true value (ie not the displayed value if user datums are in effect).

1. Key 30 to obtain the third page of the menu.
2. (a) Key 31 if it is required to set a user datum for voltage only.
   (b) Key 32 if it is required to set a user datum for time or events, depending on which was selected for the X parameter measurement (section 3.15.1).
   (c) Key 33 if it is required to set a user datum for voltage and time or events.
3. Keying 31, 32 or 33 produces a mixed display and gives the [ ] push button an "execute" function. Set the current cursor to the required position on the waveform and press the [ ] push button. The current cursor setting will now appear on the second page of the menu (key 20) as the current user datum selection (voltage and/or time or events). However, the current cursor setting(s) appearing on line 15 of the mixed display will be zero only if user datums have been switched on (key 21).

3.15.3 CALCULATIONS

1. Key 40 to obtain page 1 of the Calculation menu. Seven calculation options are available, 41 to 47, which enable the cursors to be used for carrying out time or event and voltage calculations.
2. Keying any of the seven options will produce a mixed display with the instruction "specify cursors" (except for option 44 when all four cursors are used). Specify the cursor(s) by means of the numeric push buttons on the keypad. The calculation will then proceed, with the result displayed on line 15.
   (a) Voltage and time between cursors is automatically calculated by (Key 41) and specifying the appropriate cursor. Measurements can be made in Voltage from trace to trace but it is limited to one sweep in time.
   (b) Rise or fall time and overshoot (key 42). With this option, one cursor defines the 0% level and the other cursor the 100% level of a step waveform. Rise or fall time is measured between the 10% and 90% levels, and the maximum overshoot (positive or negative) is measured as a % swing.
   (c) Voltage and time at 50% point (key 43). As with option 42, the specified cursors define the 0% and 100% levels of a step waveform, and the voltage and time at the 50% level is measured.
   (d) Period between two at the 50% points (key 44). With this option the duration of a pulse waveform at its 50% amplitude points is measured e.g. C1 defines the initial 0% level, the 100% level is found automatically (allowing for droop on the top of the pulse, if necessary) and C3 the final 0% level.
   (e) Maximum positive-going voltage swing between two specified cursors (key 45).
   (f) Maximum negative-going voltage swing between two specified cursors (key 46).
   (g) Peak-to-peak voltage between the maximum positive-going and negative-going voltage swings between two specified cursors (key 47).
3. Selecting the SHIFT control for any purpose (section 3.7) while in the Calculation Mode will suspend the calculation in progress. The current calculation result will appear on line 2 of the mixed display and current cursor details on line 15. The calculation will resume immediately the SHIFT control is deselected.
4. Press the Q push button in order to exit from the current calculation routine.
5. Calculations are suspended while repositioning cursors.

3.16 SOFTWARE CALIBRATION

The basic analogue accuracy of the 5110 is ±3%. For cursor-based measurement purposes this accuracy can be improved by calibrating the instrument against known standards. This is known as software calibration and the options available are listed in the Software Calibration menu (key S6, 50). The known standard for time is the instrument's own internal crystal-controlled timer/counter. Vertical calibration, however, requires the use of an external power supply and an accurate digital voltmeter, or an oscilloscope calibrator.

3.16.1 HORIZONTAL CALIBRATION

Options 51 and 52 enable the calibration of the A and B timebases respectively. The procedure in each case is identical.

1. Key 51, or 52, and follow the instruction "SELECT 0.1ms/DIV" by setting the appropriate TIME/CM switch to 0.1ms/cm.
2. The legend "SELECT NEXT RANGE" indicates that software calibration on that particular range has been completed satisfactorily. Set the switch to its next position (either up or down).
3. Repeat this procedure for all of the required (or all 22) positions of the TIME/CM switch. In the event of the legend "OUTSIDE S/W CALIBRATION RANGE RETRY YES/NO?" appearing instead of "SELECT NEXT RANGE", keying (Y) will cause the software to attempt to recalibrate, while keying (N) will cause it to abort the attempt.
4. Press the Q push button in order to exit from the current calibration routine.

3.16.2 VERTICAL CALIBRATION

Options 53 to 56 enable the calibration of the CH1 and CH2 amplifiers with and without a x10 probe. These procedures are more complicated than the horizontal calibration (section 3.16.1) in that they required the use of an external floating power supply and a digital voltmeter (Fig. 3.5) or an oscilloscope calibrator (eg Bradley Type 192).

NOTE: When using an external power supply and DVM, it must be possible to change over the polarity of the input without affecting the DVM reading.

1. (a) Key 53 to calibrate CH1 from a x10 probe.
   (b) Key 54 to calibrate CH2 from a x10 probe.
   (c) Key 55 to calibrate CH1 from its BNC input.
   (d) Key 56 to calibrate CH2 from its BNC input.

NOTE: Only three ranges are checked with options 53 and 54, but all ranges are checked with options 55 and 56.

2. The appearance of the legend "NOT YET WARM CONTINUE YES/NO?" indicates that the instrument has not been switched on for its full 20-minute warm up period. In this event, keying (Y) will cause the software to proceed with the vertical calibration, while keying (N) will cause it to abort.
3. Follow the instructions as they appear on the mixed display. These will give details of the range to be selected.
4. The procedure for using an external power supply and DVM is as follows.
   (a) Supply the input voltage requested to within 10%.
   (b) Answer question "IS THIS TRUE VALUE YES/NO?" by keying (Y) if the DVM indicates that the input voltage is absolutely correct, or (N) if it is not. In the latter case use the numeric push buttons to specify the voltage read on the DVM, keying SQ for decimal point if required followed by the units: S0 for volts or S1 for millivolts.
   (c) Answer question "IS THIS TRUE VALUE YES/NO?" by keying (Y).
   (d) Operate the changeover switch (Fig. 3.5) when instructed to "REVERSE POLARITY OF INPUT".
   (e) Press the [ ] push button to continue with the next value of input voltage. Instructions will be given when to change range.
5. When using an oscilloscope calibrator, the exact input voltages requested can obviously be used and the question "IS THIS TRUE VALUE YES/NO?" always answered by keying (Y). The vertical calibration program has been arranged with the Bradley Type 192 in mind in order to minimise the number of operator steps. This is illustrated by the following example detailing the procedure when calibrating the 2mV/DIV and 5mV/DIV ranges.
   (a) The first input voltage requested for the 2mV/CM range is +6mV. This is obtained by setting the calibrator controls to 2mV/DIV and 3 divisions (2 x 3 = 6mV).
   (b) Answer "IS THIS TRUE VALUE YES/NO?" by keying (Y).
   (c) Reverse the polarity to - on the calibrator when instructed to "REVERSE POLARITY OF INPUT".
   (d) Press the [ ] push button to continue.
   (e) The next input voltage requested is -15mV. This is obtained simply by setting the calibrator to the next range (5mV/DIV) and leaving the divisions control on 3 (5 x 3 = 15mV).
   (f) Answer "IS THIS TRUE VALUE YES/NO?" by keying (Y).
   (g) Reverse the polarity to + on the calibrator when instructed to "REVERSE POLARITY OF INPUT"
   (h) Press the [ ] push button to continue.
   (i) When instructed to do so, switch the 5110 to the 5mV/CM range. Since the first input voltage requested for this range will be +15mV, it will be seen that the entry conditions are exactly as required for that range.
6. Press the Q push button in order to exit from the current calibration routine.

3.17 DUAL OPTION SELECTION

It is often desirable while selecting a particular mode option (say, in the Trigger Mode) to be able to switch quickly between two alternative options of one of the other modes (say, of the Horizontal Mode). This facility is provided by the D push button which may be used for switching between the selections 1 and 2 appearing on the Dual Option menu. This menu may be viewed by selecting 60 from the General Mode Index (key S6). Alternatively it may be viewed at any time by keying SD, and the display then returned to the current display by keying Q with no changes made.

When making selections on the dual option menu the question "PRESERVES CURRENT DISPLAY Y/N?" must be answered "yes" (Y) or "no" (N) before being able to proceed.

(a) If the question is answered "no". Whenever the D push button is pressed in order to switch between the dual selections, the display will always switch to the page associated with that selection.

(b) If the question is answered "yes". It is possible to use the D push button while viewing another menu and have that menu remain on display while the dual mode selection is switched from one to the other.

1. Select the first of the required alternative options (eg for horizontal mode A timebase only, key S7, 01).
2. Key SD to obtain the Dual Option menu.
3. Answer the question "UPDATE SELECTION 1, 2 or both?" by keying 1.
4. Answer the question "PRESERVES CURRENT DISPLAY Y/N?" by keying (Y) or (N) as required (see above).
5. After a brief pause the display will revert to the menu from which the alternative selections are being made (in this example the Horizontal Mode menu). (Press Q to terminate the pause).
6. Select the second of the required alternative options (eg for horizontal mode A alternate B timebase, key 04).
7. Key SD to obtain the Dual Option menu again.
8. Answer the question "UPDATE SELECTION 1, 2 or both?" by keying 2.
9. Answer the question "PRESERVES CURRENT DISPLAY Y/N?" by keying (Y) or (N) as required (see above).
10. Once again, after a brief pause the display will revert to the menu from which the alternative selections are being made.
11. Either, or both, of the alternative options can be amended at any time by following a similar procedure.

In the above example, it is now possible while making a selection in another mode, to switch the horizontal mode from option 01 to 04 and back to 01 simply by the sequential operation of the D push button.

If both are set to 19 in memory mode for example, each time the D push-button is selected, the 5110 will arm ready for capture.

3.18 SELF TEST

Key S6, 70 to obtain the Self Test menu.

No information on this menu is available at present.

3.19 MAINTENANCE/CALIBRATION

Key S6, 80 to obtain the Maintenance /Calibration menu.

No information on this menu is available at present, but it is intended that it will provide information for the maintenance technician on the repair and calibration of the instrument. The calibration procedures will be additional to the software calibration discussed in section 3.16.

3.20 X-Y MODES

The selection of the X-Y mode (option 05 of the Horizontal Mode - section 3.11) disables the timebase and the X deflection is derived from the selected A trigger signal. The x10 expansion on/off facility (option 11 of the Horizontal Mode - section 3.11) is inoperative in this mode.

3.20.1 EXTERNAL X FUNCTION

External X operation is achieved by the selection of EXT trigger (section 3.5) while applying the signal to the EXT A input socket. The deflection sensitivity will be approximately 50mV/cm (500mV/cm with EXT 10 selected. The COUPLING locking push buttons (section 3.5) can be used as required.

This external X deflection can be displayed as a single trace display against the CH1 or CH2 input, or thier sum or difference (options 01, 02, 06 respectively of the Vertical Mode - section 3.12). Alternatively, a dual trace display of both the CH1 and CH2 inputs against the X signal is obtained by selecting the chop mode dual display (option 05) is not available in X-Y display.

3.20.2 X-Y FUNCTION

The full flexibility of the two Y input channels can be utilised for a single trace X-Y display by the selection of CH2 as the A TRIGGER SOURCE and CH1 as the vertical mode (option 01). It is recommended that DC trigger coupling is selected without the use of the LF REJ or HF REJ filters. AC coupling of the trigger signal is best achieved by the relevant Y channel (CH2)

input coupling switch (section 3.3). In this mode X shift is achieved by selecting horizontal (◄►) shift, and the relevant (CH2) vertical shift (▲ ▼) facility is inoperative.

3.20.3 Y LINE FUNCTION

By using the instrument in the X-Y mode and selecting LINE trigger source, a display of Y versus mains frequency may be obtained.

3.21 ADDITIONAL FACILITIES

3.21.1 USE OF PASSIVE PROBE

A x10 passive probe may be used to extend the voltage range and increase the input impedance of the Y amplifiers. The input impedance of the instrument is 1MΩ shunted by 22pF. The effective capacitance of the input lead must be added to this and the resultant impedance will sometimes load the signal source. The probe will reduce this to approximately 10pF and increase the resistive element of the impendance to 10MΩ. To obtain a flat frequency response it is necessary to adjust the probe capacitance to match the capacitance of the instrument. The PB18 is designed specifically to work with the 5110.

1. Set the associated VOLTS/CM switch to 20mV/cm and the A TIME/CM switch to 0.2ms/cm.
2. Connect the probe to the 1V CAL pin.
3. Use a small screwdriver to adjust the capacitor to the probe tip or termination for a square response with no overshoot or undershoot.

3.21.2 CAL OUTPUT

The 1V CAL pin provides a positive-going square waveform of 1V±1% peak-to-peak at approximately 1kHz. Shorting this pin to ground will give a square current waveform of 1mA in the shorting link for current probe calibration.

The TIME CAL pin provides a pulse train output derived from an internal crystal source.

The output is turned on and off by keying 88 on the General Mode Menu 56. The output rate is set by keying 89 and setting the value in the range 40ns to 344 secs. The timecal output is automatically switched off when the internal clock is required for other functions in the capture and delay modes.

3.21.3 DATA INPUT

External data may be connected to the 5110 via the 25-way D-type front panel connect DATA INPUT. This provides for up to 8-bit parallel data. Also available on the connector are +5V, −5V and 0V power supply lines for driving the PB100. The data word is displayed in Binary or Hex and relates to the information present at the time of the current cursor. The PB100 has the facility to identify separately a trigger word for use in conjunction with the external trigger inputs A or B. Switches are located on the PB100 to identify the trigger word required and have positions logic 0.X (don't care) or logic 1. The threshold can be rtl, ecl or variable. There are also two qualifiers which can be used to expand the trigger word to 10 bits wide. When the current cursor data display coincides with the trigger, the word flashes.

3.21.4 Z MODULATION

A rear panel socket allows dc coupled blanking to be applied to the crt. The trace is blanked by a positive input, negative inputs have no effect. The input impedance is approximately 2kΩ, and the required amplitudes are:

(a) +1V for visible modulation.

(b) +4V for blanking at normal intensity.

3.21.5 REAR PANEL OUTPUTS

In addition to a standard IEEE interface connector, there are five BNC and two 2mm sockets on the rear of the instrument providing the following outputs.

1. A ramp, a 2V positive-going sawtooth waveform from a 50Ω source impedance.
2. B gate, a dc level of approximately +3V going to ground for the duration of the B sweep.
3. Plotter outputs (section 3.14.2) at a nominal 50Ω output impedance:
   (a) For use by a recording oscilloscope on three BNC sockets (X and Y deflection and Z modulation).
   (b) For use by a pen recorder on two BNC sockets (X and Y deflection) with "pen lift" (analagous to Z modulation) on the pair of 2mm sockets.

3.22 COLD START

So far in this section we have assumed a warm start for the 5110. However, in the event of a cold start, which by definition means that no operational modes have been specified, the instrument software will select the default settings for all modes. Therefore, the alphanumeric display obtained shortly after switching on will be the Power Up Report (Fig 3.4).

Pressing the Q push button will then cause the Current Control Settings page 1 to be displayed. The procedures then for selecting the required operational modes are as described previously.

After the initial 20-minute warm-up period the legend

"COMPLETE CALIBRATION REQUIRED
SELF ADJUST DAC Y/N?"

appears on whatever display is being viewed. If it is

answered by keying (Y), then adjustment of the digital-to-analogue converter is carried out automatically and the display is retained. However, if it is answered by keying (N) it will continue to reappear at approximately 5-minute intervals until it is answered "yes".

It must be noted, however, that certain fault conditions affecting the RAM and ROM stores also constitute a cold start. In general terms these can be considered as two types, referred to as fatal errors and non-fatal errors.

3.22.1 FATAL ERRORS

A failure of the software programming memory is indicated by the legend "ROM FAILURE-FATAL ERROR" or "FATAL ERROR - NON VOLATILE RAM FAILS R/W" appearing on the display.

In the event of a fatal error, none of the software-controlled mode options will be available, but the manual Y amplifier, timebase and trigger controls will still function normally thereby allowing the instrument to be used as a simple oscilloscope locked in the dual trace, auto trigger condition. There will be no shift control, no cursors and no text display.

3.22.2 NON-FATAL START-UP ERRORS

There are six possible non-fatal error conditions and if any one or more of these occur they will be listed on the display. None of them, in any combination, are capable of completely disabling the instrument, they simply mean that certain facilities may or may not be available.

(a) Memory store 1 failed read/write test. ST1 cannot be used (section 3.14).

(b) Memory store 2 failed read/write test. ST2 cannot be used (section 3.14).

(c) Cursor store failed read/write test. No cursors are available on the stored displays.

(d) Text store failed read/write test. Some text items may not appear or may be incorrect. Beware of proceeding if this error is known to be present.

(e) Memory corrupted and all defaults used. The warm start stored data has been lost and the software has carried out a conventional cold start. Check the condition of the internal nickel-cadmium back-up battery.

(f) Reselection of stored settings has failed and default settings have been used. One or more of the operational modes cannot be set up as per the warm start stored data and the software has selected defaults instead. This is usually the result of switching the instrument off while it is actioning a menu selection.

Pressing the Q push button will then cause the Current Control Settings page 1 to be displayed.

3.23 IEEE INTERFACE

OVERVIEW

The interface will allow a bus controller to read and/or change the state of the functions operated via menu control (although not necessarily in an identical manner). Additionally access is given to all shifts, attenuator controls, timebase controls, channel source coupling, trace stores and machine states.

Calculations may be initiated on a single shot basis with the 5110 producing a service request when the calculation result is available.

Service Request is used to indicate errors, interaction between controller and a particular function and interaction between controller and operator (see detailed information and possible extensions).

When operating without a bus controller, the instrument is capable of sending and receiving store data and machine state (s) in a way which enables two 5110's to communicate

3.23.1 IEEE MODES

Before operating the 5110 through the IEEE bus, the following selections must be satisfied on the General Menu (56) Page 90:-

(a) When communicating with other equipments on the bus, the primary address must be set by keying 91 (Address available 0–31).

(b) For use with a controller where the communication is both to and from the instrument, the 5110 must be in the addressable mode (key 92).

(c) The 5110 can be operated in the talk only mode or listen only mode set by keying 93 or 94. This will enable data to be transferred between instruments or stored information to be printed. The data to be transmitted is specified and started by keying 95 or Store 1, 96 for Store 2 and 97 for the machine states. The data can be separated by carriage return, line feeds known as blocks. Zero length will give continuous data output.

3.23.2 DEFINITIONS (In accordance with recommendation of BS6146/IEC 625–2)

A STRING

Is the smallest complete message unit e.g: VS1=3.12.Comma may be used within a string as a separator, semi-colon is used to separate strings from each other.

A BLOCK

Is a collection of strings. It is merely used in the 5110 to break up bulk transmissions. Blocks are separated by CR LF (Carriage return, line feed).

A RECORD

A record contains a number of strings or blocks and is terminated by CRLF. The instrument will accept one record into its input buffer before actioning it (excepting mass data,.)

When the instrument transmits, it will issue one record for each interrogative command in the record in the input buffer.

Note that when the 5110 is receiving a record, the correct method of termination is CRLF with EOI asserted with LF. However, the CR is completely optional and is ignored; if necessary the LF can be left out as well, so long as EOI is asserted with the last character of the record; and finally, if LF is used to terminate the record, then EOI does not need to be asserted. So valid record terminators are:

record	CR LF	(with EOI)
record	CR LF	
record	LF	(with EOI)
record	LF	
record		(with EOI)

EOI signifies to the 5110 that the talker has nothing more to say, so, in the case of multi-record commands (e.g: "ST1"), EOI should be sent only at the end of the last record, otherwise it will signify the end of the command, and no more strings or records will be excepted.

3.23.3 OPERATION

The 5110 processes commands sent as ASC11 (ISO–7) Blocks Records. The instrument will perform no operations or checking until a LF is received. At any point until the LF has been received CTL – X may be used to expunge the current block from the 5110's input buffer and DEL may be used to remove the last sent character spaces and other characters of hex value less than 30 (with exceptions as specified) will be ignored to ease syntax requirements. Text within brackets ( ) will be ignored to allow comments in self – documenting command sequences. (Note that a right bracket will be assumed upon receipt of LF).

Most commands have an assertive and an interrogative form PARAMETER – CODE = Setting will perform the change indicated while PARAMETER – CODE is a request for the current setting to be transmitted.

e.g:	VP1	(CONTROLLER)
	VP1 = 3.1 E+00	(5110 Vertical position CH1 = 3.1cm)
	VP1 = 6.2	(Controller changing shift value)
	VP1	(Controller)
	VP1 = 6.2 E+00	(5110)

Assertive commands can only be sent when remote or listen only. If an assertive command is sent when local, it is ignored.

When local there is a general 30 second time out on the bus transactions to prevent the instrument being locked up permanently. Thus, if the controller send an interrogative command, but does not listen for the reply, the 5110 will keep trying to send its response for 30 seconds and will then time out.

Special ASCII Characters

"	start or terminate a taxt string
'	(Single quotes)
(	start of comment
)	end of comment
#	string header (as part of numeric base identifier)
*	family descriptor
+	] numeric sign
-	]

DEL (S7F)	delete last character
CTL –X (S18)	delete contents of input buffer

many commands can be used with a family descriptor (*) for example:-

VP* (Controller)	
VP1 = 3.1E+00]	[5110 vertical position CH1 =3.1cm)
VP2 = 2.4E+00]	[5110 vertical position CH2 =7.4cm)
VP* = 6.2	[controller changing both shift values]

In general, several commands can be combined into a record (each command being separated by ";"). The commands will then be actioned in sequence.

e.g: "VP1 = 0 ; CM =RT;ARM"
(Controller sets CH1 shift = 0
capture mode to Real-time and
then arms for acquisition)

Commands which require numeric parameters (eg: cursor position, CP1 Delay Time, DT) have parameters that follow the recommendation of BSI6146 part 2: 1981 (NR1 & NR3). That is, numbers in scientific notation with exponent in multiples of 3 will normally be transmitted for real numbers.

e.g: DT = + 20.01E – 06
e.g: VP1 = 412.0 E+03

and numbers with no decimal point or exponent. Will be transmitted as for integers e.g: DN = 137, e.g: BL = 80 when receiving numeric parameters from the bus the requirements are, in general, more relaxed:

1) The number must contain less than 14 characters.
2) The number can contain but need not contain a decimal point.
3) The number can contain but need not contain a sign ("+" or "–").
4) The number can contain but need not contain an exponent.
5) The exponent is pre-fixed by "E".

6) The exponent can contain but need not contain a sign.

7) The exponent must not contain a decimal point.

8) If no sign is included, "+" is assumed.

Note that bulk data transfer commands (e.g: ST1) have stricter syntax requirements see page Appendix A.

3.23.4 VERTICAL MODE

COMMAND			OPTION
VM	(VERTICAL MODE)	= CH1	01
		CH2	02
		DUAL	03
		CHOP	04
		ALT	05
		ADD	06
TV	(TRIGGER VIEW)	= 1 ON	)09
		0 OFF	)09
P	[1] (PROBE)	= X1	)
	[2]	X10	)11 & 12
	[*]		
VP	[1] (VERTICAL POSITION)	= SIGN NUMBERS	
	[2] (Y SHIFT)	(DIVS)	
	[*]		
VS	[1] (VERTICAL SCALING)	= for UNCAL SIGN	
	[2]	NUMBERS	
	[*]	(V/DIV)	
		└── 07,08	
VC	[1] (VERTICAL COUPLING)	= AC	
	[2]	DC	
	[*]	GND	

Note that assertive commands VS*, VC*, and HS* can be used to change the main control settings.

e.g if "VS1 = 56–3" is sent, a message will appear on the screen, requesting the appropriate manual control change, until the control is in the correct position.

3.23.5 HORIZONTAL MODE

COMMAND			OPTION
HM	(HORIZONTAL MODE)	= A	01
		INTEN	02
		B	03
		DUAL	04
		XY	05
B	[1] (ENABLE B1(3))	= 1 (on)	06,07
		0 (off)	
HE	(HORIZONTAL EXPANSION	= 1	11
	(X10 EXPANSION)	0	
XC	(X TRACKS CURSOR)	= 1	12
		0	
HS	[A] (HORIZONTAL SCALING)		
	[B]	= for UNCAL NUMBER	
	[*]	(TIME/DIV)	
HP	(HORIZONTAL POSITION)	= SIGN NUMBER	
	(X SHIFT)	(DIVS)	

3.23.6 TRIGGER MODE

COMMAND			OPTION
SM	(SWEEP MODE)	= NORMAL	01
		AUTO	02
AS	(A SWEEP START)	= TRIGGER	11
		DELAY	12
AD	(A SWEEP DELAY	T	21
	CONFIGURATION)	N	22
		A/N	23
		CLK	24
BS	(B SWEEP START)	= C	13
		C + TR	14
		D	15
		D + TR	16
		BTR	17
		AS	18
		C + D	19
		TCAL	88
		General Mode	
BD	(B SWEEP DELAY	= AS	31
	CONFIGURATION)	BTR	32
		C	33
		C + BTR	34
		ATR	35
		C + ATR	36
	,	T	37
		N	38
BD		OR	
		TR/N	39
DT	(DELAY TIME)	= NUMBER	41
		(SEC)	
DN	(DELAY NUMBER)	= NUMBER	42
		(UNITS)	
DST	(DELAY STEP TIME)	= NUMBER	43
		SEC	
DSN	(DELAY STEP NUMBER)	= NUMBER	43
		UNITS	
PH +	/* (PHASE ADVANCE BY ONE STEP)		45
PH –	/* (PHASE RETARD BY ONE STEP)		

/* NO INTERROGATIVE FORM

3.23.7 MEMORY MODE

COMMAND			OPTION
DS	[1] (DISPLAY OF STORE)	= 1 (ON)	01,02
	[2]	0 (OFF)	
	[*]		

CS	(CAPTURE SOURCE)	=	CH1	11
			CH2	12
			DUAL	13
	,		A	14
			B/B1	15
			B3	16
CD	(CAPTURE DESTINATION)	=	S1	17
			S2	18
			DUAL	13
ARM	/* (START CAPTURE)			19
GET	/* (ARM FOR CAPTURE, TRIGGER ON "GET")			-
CM	(CAPTURE MODE)	=	RT	21
			REP	22
PT	(PRE-TRIGGER)	=	0	23
			50	24
AV	(NO: OF AVERAGES)	=	NUMBERS	25
PS	(PLOT SOURCE)	=	S1	31
			S2	32
PR	(PLOT RATE)	=	NUMBERS	37
PLOT	(START OR	=	ON	38
	STOP PLOT)	=	OFF	39
/* NO INTERROGATIVE FORM.				
PLX	(SET PLOT X OUTPUT TO MAX)			42
PLY+	(SET PLOT Y OUTPUT TO +MAX)			42
PLY–	(SET PLOT Y OUTPUT TO –MAX)			43

3.23.8 CALCULATION MODE

COMMAND				OPTION
XP	(X PARAMETER OF CURRENT CURSOR	=	AUTO	11
			XTAL	12
			EVNT	13
DD	(DATA WORD DISPLAY)	=	1 (ON)	14
			0 (OFF)	
DC	(DATA WORD CODING)	=	1 (HEX)	15
			0 (BINARY)	
HD	(MACHINE HORIZONTAL TIME DATUM)	=	A	34
			B	35
			AUTO	36
UD	(USER DATUM)	=	0 (ON)	21
			1 (OFF)	
UV/*	(C.C. VOLTAGE – USER DATUM)			31
UT/*	(C.C. TIME – USER DATUM)			32
UB/*	(C.C. VOLTAGE – & TIME – USER DATUM) (BOTH)			33

U12 (C1 & C2 User Datum)
value = NUMBER, NUMBER, NUMBER

U34 (C3 & C4 User Datum)

value	22	23	24
	volts	time	events

If a NUMBER is missed out when sending the string then that value will not be changed.

e.g "V12 = ,, 12" will change C1 & C2 user datum events to 12, while not changing their time and voltage user datums.

A calculation is initiated by the "CA" command.
A service request will be issued when the result is ready; the latter is read via the "RS" command.

		OPTION
CA =	CP1	
	CP2	
	CP3	
Current cursor type reading:	CP4	
	CS1	
	CS2	
	CS3	
	CS4	

Voltage Between	DIFF		41
Rise Time + Oshoot	TR		42
V & T @ 50%	VT50		43
Period	PER	At between	44
V + MAX	MAX	specified Cursors	45
V – MIN	MIN		46
Peak to Peak	P–P		47

The format is e.g: "CA = CP1"
or: "CA = DIFF,C1,C3"
or: "CA = MIN,C2,C3"
or: "CA = PER,C3,C4"

RS = CRLF

Or string of the form
e.g: "RS = CP1,–4.21E+00,21E–03"
or: "RS - DIFF,C1,C3,2.13E+00,6.53E–06"
or: "RS = MIN,C2,C3,2.70E+00,1E–20"
or: "CA = PER,C3,C4,27E–6"

Note: Quotes shown for clarity only.

Calculations are of two general types; current cursor reading and calculations between cursors.

Current Cursor Calculations

These measure the voltage and time at a particular cursor for example:- "CA = CP3" requests the reading on the realtime trace at cursor 3 position, and "CA = CS2" requests the reading on a stored trace at cursor 2 position. If both stores are turned on, CS1 and CS2 will be on store 1, CS3 & CS4 on store 2. If both real-time channels are turned on C1 and C2 will be on CH1,C3 and C4 on CH2.

The result of the calculation is requested by the command "RS". The response to this is of the form:

+"RS CP3, –3.232E+00, 82.00E–06"

Where the first numeric parameter is the voltage and the second is the time in seconds. Note that if the X-parameter

of current cursor is set to B trigger even to (i.e: XP = EVNT) then the second numeric parameter will be the integer number of B trigger events to the cursor (and not time to the cursor).

Calculations Between Cursors

The calculations correspond to Calculation Mode options 41 to 47. They require two cursors to be specified as parameters.

The format is:

CA = calculation , cursor , cursor

The result is requested by command "RS". The response depends on the calculation last performed as follows:

RS = DIFF , cursor , cursor , volts , time .
RS = TR , cursor , cursor , volts , overshoot
RS = VT50 , cursor , cursor , volts , time ,
RS = PER , cursor , cursor , time ,
RS = MAX , cursor , cursor , volts , time
RS = MIN , cursor , cursor , volts , time
RS = P–P , cursor , cursor , volts ,

If a part of either type of calculation is unsuccessful, for any reason (eg: Uncalibrated Y-Amplifier, or ADC overrange) the value for the unobtained parameter is given as " 1E – 20 " for ease of detection.

3.23.9 GENERAL MODE

COMMAND			OPTION
RESET /* SELECT DEFAULT SETTINGS			41
|*			
UNC (RESET SOFTWARE CALIBRATION FACTORS)	=	H	82
		V	83
		P	84
TC (TIME-CAL)	=	1 (ON)	88
		0 (OFF)	
TP (TIME-CAL PERIOD)	=	NUMBER	89
CAL = [A, B, CH1, CH2, P1, P2] /* (SOFTWARE CALIBRATION)			51, 52, 55, 56, 53, 54

Software calibration when remote users exactly the same sequence as when local, except that response is expected from the GPIB, not the keypad.

Whenever a reply is required from the controller, the serial poll value changes from 16 (busy) to 0 (not busy), and a response must be sent over the bus. A series of responses may be sent, separated by commas or semi-colons and terminated by CRLF. If at any time the calibration for B, the sequence is terminated and a "selection failure" SRQ is sent. On successful completion of the calibration, a "completed" SRQ will be sent.

A typical sequence sent by the controller might be:-
CAL = CH1, Y,N, 6.03E – 3,Y CRLF

Thus requests s/v cal of CH1, this range only 6mV is not time value, 6.03E–3V is time value.

Then wait for serial poll is not busy and reverse polarity of input and send:
" [" CRLF ie continue.
then wait for serial poll not busy and input –15mV and send "Y" CRLF i.e.15mV in time value.
Then wait for serial poll not busy and reverse polarity of input and send " [" CRLF i.e continue.
Then wait for serial poll "completed".

/* NO INTERROGATIVE FORM.

3.23.10 MISCELLANEOUS COMMANDS

CP [1, 2, 3, 4, *] = NUMBER
Cursor Position In Divs:

CS [1, 2, 3, 4, *] = NUMBER
Store Cursor Position In Divs:

BL = NUMBER Specifies maximum Block Length

NB (Numeric Base) = OCT (ASC11) | CHOICE APPLIES
BIN | TO BULK TRANSFER
HEX (ASC11) | ONLY ie: ST1, ST2
DEC (ASC11) | AND MS* AND MSS*

ALL (Interrogative Only) will output the entire state of the instrument as if all interrogatives had been sent.

CA [1, 2, 3, 4, 5] = 1 (ON) Turn On Or Off cursor.
0 (OFF) (Cursor Activation)

(Service Request)

In addition to indication of error and previously mentioned messages to the bus controller, 9 service request status values are allocated to the keys 1 through to 9 in REMOTE Mode. This, together with the text (TXT) option allows user defined interraction between bus controller and operator.

SRQ = 1 (On) enable/disable SRQ's
0 (Off)

If required, all SRQ's can be disabled, using "SRQ = 0" to find out if a command was successful "SRQV" can be used.

SRQV /* responds with the value of the last SRQ to be sent (or that would have been sent if not disabled).

ERRV /* responds with an error number indicating a reason for a selection failure.

/* NO INTERROGATIVE FORM.

TXT = " ASCII STRING " Send of receive screen text. .

The command TXT responds by transmitting the contents of

the displayed screen as a string of 512 bytes preceded and terminated by quotation marks. The bytes correspond in general to the ASCII standard, except for special characters which are given values between 0 and 20.

The command can be used to send characters to the screen, when remote, in which case the header is sent followed by the request string in single or double quotations marks (" or '). The ASCII character for line feed (Value 10 or hex value OA) moves the following characters to the start of the next line. Note that input buffer is only 256 characters and this limits the number characters that can be sent to the instrument at any one time.

(e.g: TXT = ' LF LF LF Hello,hello,hello')

CLS /* CLEAR SCREEN.

If the 5110 is in LOCAL mode, it will not respond to programming commands (this is a requirement of the IEEE specification) nor will it store them for use when it enters REMOTE mode.

RS [1 2 3 . . . . 8 *] /*

recall machine state as RS key.

SS [1 2 3 . . . . *] ,Y /* Save machine state
,N as SS key but:
,Y causes manual controls to be included
,N does not
,N is assumed if nothing sent

RESET /* recall machine state 0 (ie. the default settings)

/* NO INTERROGATIVE FORM.

3.23.11 MASS DATA COMMANDS

MS [1 2 3 . . . . 8 9 *] Will cause the contents of the specified machine state to be input or output as appropriate details as defined in Appendix A. The machine state is in a compressed form not readily readable by the user.

Note: the special case of MS9 which will output the current machine state or input and use a machine state.

ST [1 2 *] Will cause the contents of the specified store to be input or output as appropriate, as mass data as defined in Appendix A; this is followed by information about the store capture source.

e.g: ST1 = 1,2. . . CRLF [VERTICAL], [HORIZONTAL], [CENTRELINE], [BLANKA], [BLANK B], [MISC] CRLF

Where

[VERTICAL] is an exponent type number (NR3) respesenting the vertical scaling in volts/Div.

[HORIZONTAL] is an exponent type number (NR3) representing the Horizontal scaling in seconds/Div.

[CENTRELINE] is an exponent type number (NR3) representing the centre line value in volts.

[BLANKA] is an integer (NR1) in the range 0–99 pointing to the first brighted-up store location.

[BLANK B] is an integer (NR1) in the range 0–99 representing the offset from one brighted-up location to the next, decremented by one.

[MISC] is an integer in the range 0–9215 (NR1) representing a 16 bit, bit organised number, defined as follows:-

BIT NUMBER	BINARY WEIGHTING	DEFINITION
15		ALWAYS ZERO
14		ALWAYS ZERO
13	8192	1 = TIMEBASE B, 0 = TIMEBASE A
12,11,10		ALWAYS ZERO
9	512	1 = REAL TIME 0 = REPETITIVE
8	256	1 = HORIZONTAL UNCAL
7,6		ALWAYS ZERO
5	32	1 = CH2,0=CH1
4	16	1 = INVERTED
3	8	1 = X10, 0 =X1
2	4	1 =AC, 0=DC
1	2	1 = SIGNAL 0 = GROUNDED
0	1	1=VERTICAL UNCAL

NOTES:

1. The absolute voltage represented by the contents of any store location may be calculated as follows.

   Voltage = Contents (−128 to +127) *[VERTICAL] *0.032
   + [CENTRELINE]

   In the example shown below the first location represents.

   −36 * 2.00 * 0.032 + 7.232 = 4.928 volts.

2. The time represented by any store location with respect to the first location may be calculated as follows:

   Time = location (0 to 1023) * [HORIZONTAL] * 0.01

   In the example shown below, the time represented by the second shown location is:

   1 * 20E − 6 X0.01 = 200ns.

3. The construction of [BLANKA] & [BLANK B] is such that 0,0 represents all locations brighted-up. If a store had been acquired by expanded real-time, ie: real time above .1ms/Div as in the example, only the brighted-up locations contain valid samples.

   Thus in the example, 0,9 the first valid location is 0, then 10,20 etc:

4. The [MISC] number contains more information than is available on the screen.

   In the example below we have:

   518 = 0000001000000110

   Capture source CH1, TBA, AC Coupled, Real-time capture not inverted , no x 10, no UNCALS.

5. If a store block is being constructed artificialy, it is sufficient to set [BLANKA] = [BLANK B] = 0 and [MISC] = 2

EXAMPLE

ST1= −36,-36..−36CRLF +2.00E+00,+20.0E−06,7.232E+00, 0,9,518 CRLF.

MSS [1 2 3 . . . 8 *]

Will cause the contents of the specified machine state stored/store 2 block to be input or output as appropriate as mass data as defined in Appendix A. The store 1 equivalent followed by the Store 2 equivalent is treated as 1024 contiguous bytes. The mass data is followed by the parameters for the store 1 equivalent then those for the store 2 equivalent details as described for ST1.

e.g: MSS 1 = 1,2 . . . . . 127 CRLF MASS DATA

+2.00E + 00, + 10.0E −06,0.000E + 00,0,0,6,CRLF
STORE 1 EQUIV

+1.00E + 00, + 10.0E −06,0.000E + 00,0,0,38CRLF
STORE 2 EQUIV

3.23.12 APPENDIX A

MASS TRANSFER DATA GENERAL

1. A family command e.g.: ST* may be used to read mass data from the instrument but not to write to it.
2. When the instrument outputs mass data, the numeric base and block length will be as specified in separate commands by the user (note: binary is continuous).
3. When mass data is sent to the instrument the numeric base is deduced from the data string (see Mass Transfer Data Format) and block length is irrelevant.
4. If the instrument is sent EOI-true with data byte, the instrument will consider the transfer terminated at that point e.g.: sending ST1 = 2,3 will cause only

   EOI

   the first two store locations to be changed and the store parameters to be left unchanged.

MASS TRANSFER DATA FORMAT

Mass data consists of three main sections:−

1. A header which is specific to the command in operation e.g.: ST1 =
2. A numeric base identifier (where appropriate)
   i.e. #B Binary.
   #O Octal.
   #H Hexadecimal.
   " Opening quotes for text.

   There is no identifier for decimal.

The data itself, which is as follows.

a) Binary

MS1 = #BLLDDDD . . . . CC CRLF

where LL is a byte count of the following data including the two byte checksum.

CC is a two byte checksum of all bytes 'D' (i.e. not including LL)

All eight bit characters are valid between #B and CRLF.

DD . . . . . DD represents data bytes.

Note that upon receipt of checksum CC, the instrument expects ASCII (ISO-7) only and expects LF (with or without CR)

b) Decimal

MS1 = 1,27, − 128 . . . . . +127 CRLF

1. Output is bipolar, in the range −128 to +127 producing zero for mid-screen in the case of store data and +127 at top of screen.
2. Leading zero's are not output but are acceptable when supplied.
3. Leading '+' is output but will be assured if space is supplied.
4. Values are normally separated by comma but

CRLF is substituted at the end of intermediate blocks (Block length non zero) and as the final terminator. Note that a comma preceding the final terminator will cause a syntax error.

5. If the first character following a comma is another comma, the value of zero is assumed.
e.g. 1,,3 is equivalent to 1,0,3.

6. If a value contains both + and – signs, minus will be used regardless of the order in which they appear.

c) Octal

MS1 = #0001,010 . . . . . 377 CRLF

NOTES:

1. The output is unsigned in the range 000 to 377.
2. Leading zero's are output but are not absolutely required on input.
3. Notes: (4) and (5) of decimal also apply.

d) Hexadecimal

MS1 = #H01, 0F . . . . . FF CRLF

NOTES:

1. The output is unsigned in the range 00 to FF.
2. Leading zero's are output but are not absolutely required on input.
3. Notes (4) and (5) of decimal also apply.

3.23.13 APPENDIX B

SERVICE REQUESTS

The following is a list of Service Request Values that can be sent by the 5110.

SRQ VALUE	MEANING
0	OK
16	BUSY
64–73	USER REQUESTS 0–9 (i.e.: USER PRESSED A BUTTON 0–9)
74	COMPLETED
80	BUSY
96	INVALID COMMAND
97	UACG: (UNDEFINED ADDRESSED COMMAND GROUP)
98	SRQ OVERFLOW
99	BUFFER OVERFLOW
100	SELECTION FAILURE
101	NOT ALLOWED WHEN LOCAL
102	SYNTAX ERROR
103	NUMBER OUT OF RANGE/ UNACCEPTABLE
104	LENGTH ERROR
105	CHECKSUM ERROR

In general, SRQ values below 81 can be considered non-fatal and do not affect the function of the instrument. All other SRQ's however hold up the instrument until that SRQ has been correctly serviced. Up to 10 non-fatal SRQ's may be stacked up waiting to be serviced before a fatal "SRQ Overflow" occurs. So as not to lock up the instrument when local, no service requests are sent when local.

3.24 SYSTEM ERROR MESSAGES LISTED BY ERROR NUMBER (ERRV)

1 SELECTION ABOVE AVAILABLE RANGE

2 OPTION DOES NOT EXIST

3 NUMERIC ENTRY NOT APPLICABLE

5 OPTS 3, 4 & 5 REQUIRE "B1" AND/OR "B3"
Must specify which B sweep before using it. (Option 6 or 7)

6 N/A UNTIL CURSOR 1 IS ON
Cannot enable a B1 sweep if cursor 1 is not on

7 N/A UNTIL CURSOR 3 IS ON
Cannot enable a B3 sweep if cursor 3 is not on

9 N/A UNTIL TALK ONLY

12 COUNTER ASSIGNED TO DELAY SYSTEM
Either T/B "B" or "A" is using the delay system. (see TRIGGER mode options 11–19)

15 COUNTER ADDIGNED TO TIMEBASE B
TRIGGER option 15, 16 or 19 already selected

16 COUNTER ASSIGNED TO TIMEBASE A
TRIGGER option 11 already selected

17 COUNTER ASSIGNED TO CURSORS
CALCULATION option 12 or 13 already selected

18 ERROR: OUTSIDE AVAILABLE RANGE

19 1–2–5 SEQUENCE ONLY

20 INVALID ENTRY

22 OPTION NOT AVAILABLE
e.g. starting a B sweep on trigger eliminates access to ENABLE B1 and ENABLE B3 in HORIZONTAL menu.

23 "B" TRIG N DOES NOT REQUIRE A START SELECTION

24 PHASE SHIFT ONLY APPLICABLE WITH OPTS 23, 24 AND 39
i.e. either "A" or "B" must be started by trigger divided by N or Time divided by N

25 ALTERNATE NOT AVAILABLE IN X–Y MODE

26 X–Y MODE REQUIRES NO X10 EXPANSION

27 OPTS 16 AND 19 ONLY ALLOWED WITH OPTS 31, 33 AND 39

29 ABORT
Premature termination by Quit

31 SOURCE SELECTION ERROR
Attempting to acquire from a channel not turned on

32 SWEEP SELECTION ERROR
Attempting to acquire from a sweep not turned on

33 N/A UNTIL CURSOR SELECTED

34 CURSORS MUST BE ON SAME TRACE
Cursors are dynamically allocated according to the number of real time traces and stored traces. Consult allocation table.

35 TIMEOUT FAILED
a) Indicates malfunction of ADC or Timebase hardware
b) Interruption of data flow for more than 30 sec in GPIB transfer when local.

36 *** PLOT IN PROGRESS ***
Store contents cannot be modified while a Plot is in progress.

70 "B" SWEEP ERROR: "A" ONLY SELECTED
Caused by switching from a "B" sweep which does not involve cursors to one which does when the relevant sweep is not enabled.

3.25 COMMAND SUMMARY

COMMAND		PARAMETERS	SPECIAL NOTES
AD	"A" sweep Delay	{T, N, A/N, CLK}	
*ALL	output machine state in ASCII		
*ARM	ARM single shot		
AS	"A" sweep Started by	{TRIG, DELAY}	
AV	no of AVerages	(NR3)	1,2,4,8,16 . . 256
B {1, 3}	enable "B" sweep	{0, 1}	
BD	"B" sweep delay	[{AS, BTR, C, C+BTR, ATR, C+ATR}], [{T, N}]	comma only required if both fields specified
		OR TR/N	
BL	Block Length	(NR3)	0 to 80
BS	"B" sweep Started by	{C, C+TR, D, D+TR, BTR, AS, C+D, TCAL}	
*CA	CAlculation	{CP1, CP2, CP3, CP4, CS1, CS2, CS3, CS4}	
		OR	
		{DIFF, MAX, MIN, P–P, PER, TR}, {C1, C2, C3, C4}, {C1, C2, C3, C4}	
CA {1, 2, 3, 4, *}	Cursor Active	{1, 0}	
*CAL	CALibrate	{A, B, CH1, CH2, P1, P2}	Further parameters required as Calibration sequence continues
CD	Capture Destination	{S1, S2, DUAL}	
*CLS	CLear Screen		
CM	Capture Mode	{RT, REP}	
CP {1, 2, 3, 4, *}	Cursor Position	(NR1)	0.0 to 11.46
CS	Capture Source	[{CH1, CH2, DUAL}], [{A, B/B1, B3}]	comma only required if both fields specified

CS {1 2 3 4 *} Position of Cursor on Store (NR1) 0.0 TO 10.23

DC Data pod Coding {0 1}

DD Data pod Display {0 1}

DN Delay Number (NR3) 0 TO 999999999

DS {1 2 *} Display of Store {0 1}

DSN Delay Step Number (NR3) 1 TO 999999999

DST Delay Step Time (NR1) IE–8 TO 343.597

DT Delay Time (NR1) 0 or IE-8 TO 343.597

**ERRV ERRor Value (NR3)

*GET Initialise for G.E.T.

HD Horizontal Datum {A B AUTO}

HE Horizontal Expansion {0 1}

HM Horizontal Mode {A B DUAL INTEN XY}

HP Horizontal Position (NR1) 0.0 TO 11.46

HS {A B *} Horizontal Scaling [>] [(NR1)] 50E-9 TO 0.5 in 1, 2, 5 sequence

MS {1 2 3 4 5 6 7 8 9 *} Machine State (MASS TRANSFER)

MSS {1 2 3 4 5 6 7 8 *} Machine State Store (MASS TRANSFER)

NB Numeric Base {BIN DEC HEX OCT}

P {1 2 *} Probe scaling {0 1}

*PH+ PHase advance

*PH– PHase retard

PLOT {OFF ON}

*PLX PLot output to X full scale

*PLY+ PLot output to Y +full scale

*PLY– PLot output to Y –full scale

PR Plot Rate (NR1) in 1, 2, 5 sequence

PS Plot Source {S1 S2}

PT Pre-Trigger {0 50}

*RESET recall machine state zero

**RS ReSult of calculation format depends on previous "CA" command

*RS {1 2 3 4 5 6 7 8} Recall machine State

SM Sweep Mode {AUTO NORMAL}

SRQ SeRvice reQuest {0 1}

**SRQV SeRvice reQuest Value (NR3)

*SS { 1 2 3 4 5 6 7 8 * } [, { Y N }] Save machine State

ST { 1 transfer 2 STore * } (MASS TRANSFER)

TC Time-Cal ON/OFF { 0 1 }

TP Time-cal Period (NR1) 40E-9 TO 343.597

TV Trigger View { 0 1 }

TXT "(ASCII STRING)"

U { 12 34 } User datum value [(NR1)] , [(NR1)] , [(NR3)] comma's not optional

*UB Update Both user datums

UD User Datum on/off { 0 1 }

*UNC delete software calibration (UNCal) { H P V }

*UT Update user Time datum

*UV Update user Voltage datum

VC { 1 2 * } Vertical Coupling { AC DC GND }

VM Vertical Mode { CH1 CH2 ADD ALT CHOP DUAL }

VP { 1 2 * } Vertical Position (NR1) –32.7 TO 32.7

VS { 1 2 * } Vertical SCaling [{ + – }] [>] [(NR1)] 2E-3 TO 5 in 1, 2, 5 sequence

XC X tracks Cursor { 0 1 }

XP X Parameter { AUTO EVNT XTAL }

*ASSERTIVE ONLY [OPTIONAL]

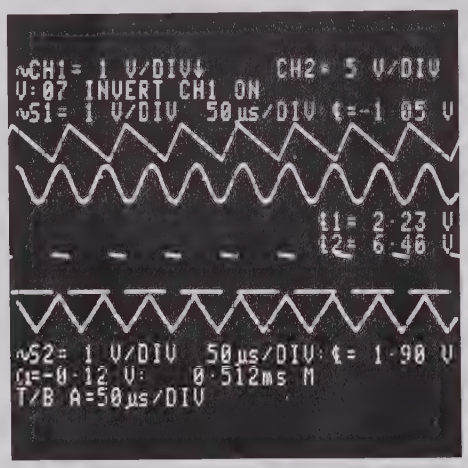
**INTERROGATIVE ONLY {ALTERNATIVES}

This indicates that the horizontal mode menu was displayed prior to obtaining the mixed display and that the mode selected was option 04 — A Alternate B.

CH1 & CH2 sensitivity settings indicating that Dual Display was selected for the Vertical Mode.

∿ indicates that CH1 is AC coupled and its absence indicates that CH2 is DC coupled.

GND appears here when the channel input is grounded. > instead of = indicates uncalibrated (ie centre variable control is in use).
:= instead of = indicates x10 probe scaling.
↓ indicates the displayed trace is inverted.


∿CH1= 1 V/DIV↓ CH2= 5 V/DIV
V:07 INVERT CH1 ON
∿S1= 1 V/DIV 50µs/DIV t=-1 05 V
t1= 2·23 V
t2= 6·46 V
∿S2= 1 V/DIV 50µs/DIV t= 1·90 V
Ω1=-0·12 V: 0·512ms M
T/B A=50µs/DIV

Voltage Levels of Sweep Centre Lines

A & B Timebase settings
> instead of = indicates uncalibrated (ie centre variable control is in use).
:= instead of = indicates X10 expansion.

Current Cursor Information.

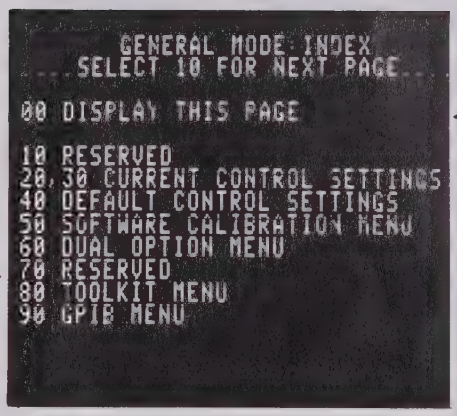
The 3-digit readout for time indicates that the X parameter measurement is in auto-time mode.

The A indicates that the Horizontal Datum is the start of the A sweep.

X would appear on this line if the Timer/Counter was being used for the time measurement, and E if time was being measured as "Number of Events" U would also appear if "User Datums" had been selected for the calculation mode.

Fig. 3.1 Typical Mixed Display

This form of instruction appears on every menu page except the last, when
.....Final Page.....
appears instead.



Keying instructions (Options) for obtaining menu pages. eg Key 20 to obtain page 1 of Current Controls Settings (see Fig. 3.3).

Fig. 3.2 General Mode : Index

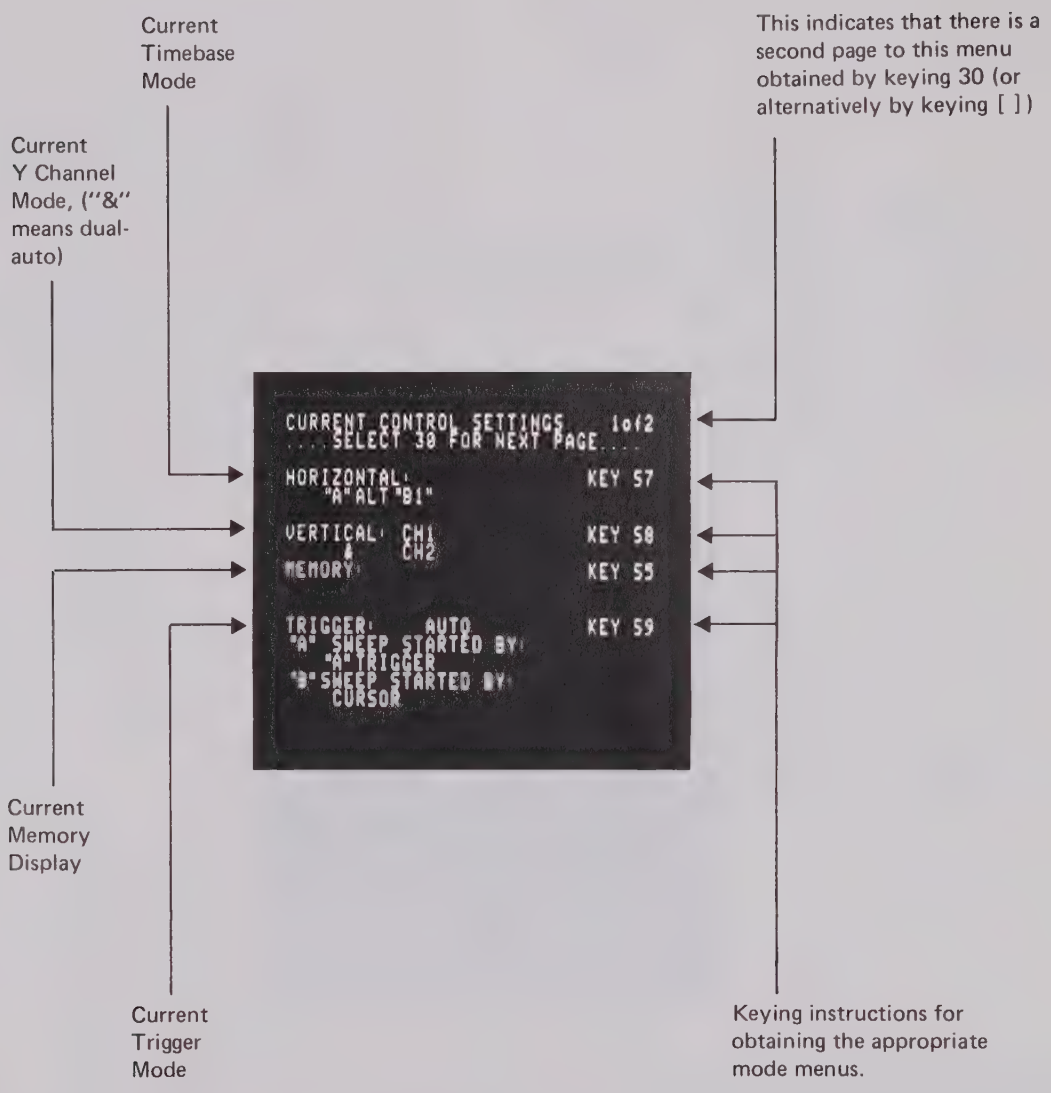
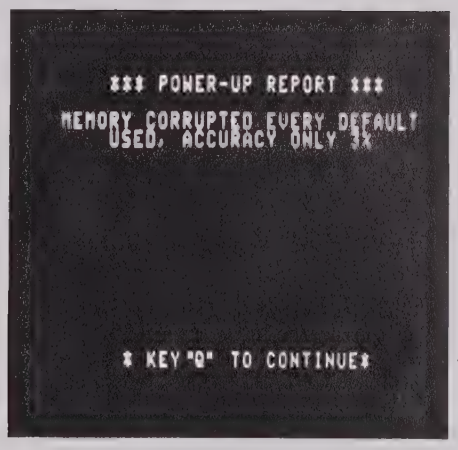


Fig. 3.3 Current Control Settings



Default conditions have been selected as No Operational Modes have been specified

Software Calibration Required

Press "Quit" in order to obtain Page 1 of Current Control Settings. (see Fig. 3.3).

Fig. 3.4 Power Up Report

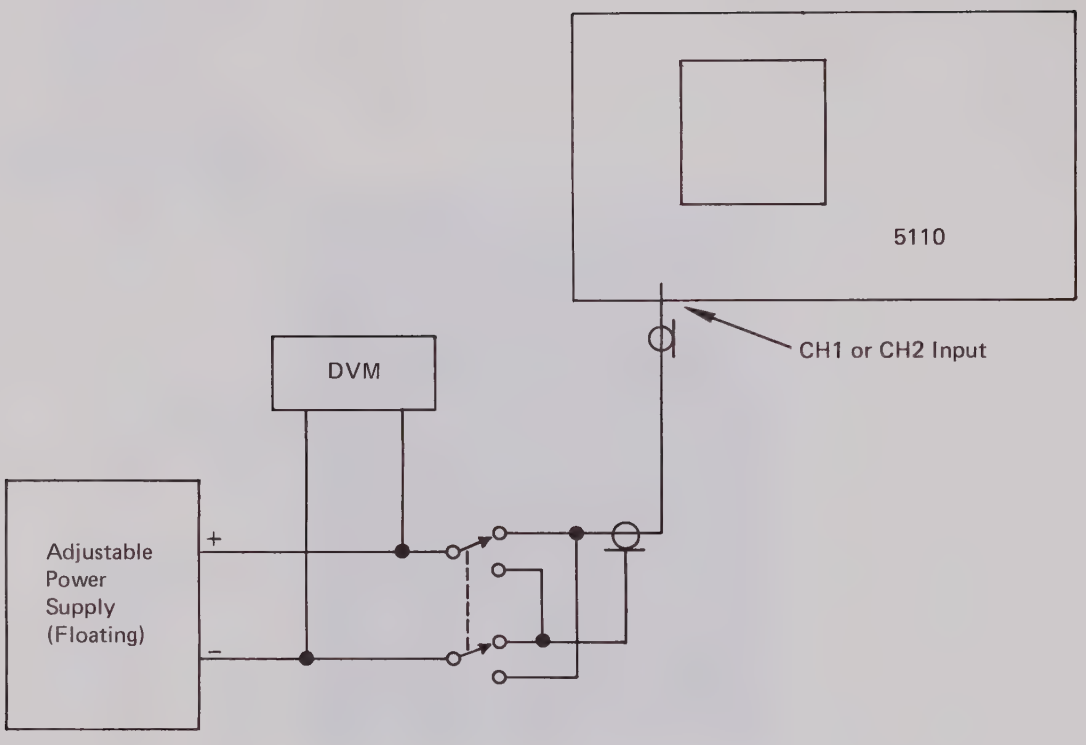


Fig. 3.5 Vertical Calibration : Connection of External Test Equipment

Guarantee and Service Facilities

Section 7

This instrument is guaranteed for a period of two years from its delivery to the purchaser, covering faulty workmanship and replacement of defective parts other than cathode ray tubes and batteries (where fitted). Cathode ray tubes are subject to the manufacturers guarantee. This assumes fair wear and tear and usage in the specified environment and does not cover routine recalibrations and mechanical adjustments.

We maintain comprehensive after sales facilities and the instrument should be returned to our factory for servicing if this is necessary. The type and serial number of the instrument should always be quoted, together with full details of any fault and service required.

Equipment returned for servicing must be adequately packed, preferably in the box in which the instrument was supplied and shipped with transportation charges prepaid. We accept no responsibility for instruments arriving damaged. Should the cause of failure during the guarantee period be due to misuse or abuse of the instrument, or if the guarantee has expired the repair will be put in hand without delay and charged unless other instructions are received.

Our Sales, Service and Engineering Departments are ready to assist you at all times.

The Service Department can provide maintenance and repair information by telephone or letter, if required.

Note: Please check fuses before returning instruments for service and ensure that any 13 Amp mains plugs fitted are removed. To prevent possible transit damage, we regret that mains plugs cannot be returned.

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